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The British Mycological Society

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Volume XVIII

Edited by

J. RAMSBOTTOM, B. F. BARNES and H. WORMALD

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Photograph of British Mycological Society's members and friends, Haslemere meeting, September 21st, 1932.

THE LUDLOW FORAY

May 27th–31st, 1932

By E. M. WAKEFIELD

The annual Spring Foray for 1932 was held at Ludlow, Shropshire, during the week-end May 27th to May 31st. Headquarters were at the Angel Hotel, where a good room was available for meetings and for the display of specimens. The week-end started wet, but a party of fifteen braved the rain on the Saturday morning and travelled by a special omnibus to Burwarton, between Ludlow and Bridgnorth. On arrival at the Boyne Arms, they were met by the head keeper of the Burwarton estate (owned by Viscount Boyne), who conducted them safely past forbidden preserves and then left them to wander at will on the slopes of Brown Clee Hill. By midday the rain ceased and members spent a happy and interesting time amongst plenty of fallen wood in the coniferous woods covering the slope of the hill. Owing to the long, cold spring the larger fungi were scarce, but amongst smaller forms several interesting finds were made. The resupinate Basidiomycetes were fairly well represented, and among others may be mentioned *Heterochaetella crystallina*, *Radulum quercinum*, and a *Peniophora*, apparently undescribed, which has now been collected in several localities. At the margin of a field *Melampsorella Symphyti* was found in abundance, in the teleutospore stage, on *Symphytum peregrinum*. After tea at the Boyne Arms some members visited the church, and in the churchyard secured *Puccinia mirabilissima* Peck (= *Uropyxis mirabilissima* Magn.) on *Mahonia Aquifolium*.

On Sunday, May 29th, the morning was kept free, as usual, and various members utilised the time in working out the material already collected. In the afternoon a short excursion was made to the woods on the Whitcliffe, but in spite of recent rain the ground there was found to be very dry, and many of the trees had been cut down in recent years. Very little of interest was recorded, but Mr Petch secured specimens of *Stromatinia baccarum* (Schroet.) Boud. growing on old fruits of *Vaccinium Myrtillus*.

The following day, Monday, was devoted to working the Moor Park estate, by kind permission of the Dowager Lady Inchiquin. The party travelled by motor to a point not far from Richard's Castle, and then worked up into Haye Park Woods and gradually back towards Ludlow, finishing in the Mary Knowl Valley before returning by a walk along the high road. The woods here were almost entirely of oak, and mycologically were not on the whole so good as those at Burwarton. But the weather on this day was perfect and the delightful

walk through the woods compensated for any dearth of specimens. *Stromatinia baccarum* was again found in fair quantity beneath *Vaccinium Myrtillus*, and the bag of resupinate fungi included a new record for Britain, *Peniophora sublaevis* (Bres.) v. Hoehn. & Litsch. *Tremella tubercularia* Berk. was common on dead twigs of oak, probably favoured by the recent spell of excessively wet weather. Along the roadside on the way back to Ludlow Mr Ramsbottom collected several rusts and other microfungi, which helped to swell the list for the day. Some additions were also made by various members during the week-end, chiefly from the ground round Ludlow Castle.

At the close of the foray a business meeting was held, when it was decided that the Spring Foray in 1933 shall be at Lyndhurst in the New Forest, provided that accommodation can be arranged. Votes of thanks were accorded to the various landowners who had given permission for us to work in their grounds, and a special vote of thanks was passed to Mr Preston, who had assisted in arranging the foray and had secured for the party a very comfortable and convenient hotel.

For help in compiling the attached list of species collected the Secretary is indebted to all members present, and especially to Mr Pearson, Mr Petch, Mr Ramsbottom, and Dr Alex. Smith. Mr Petch looked after the Mycetozoa and compiled the list of these organisms.

Complete List of Species gathered during the Foray

B. = Burwarton; *W.* = Whitcliffe; *H.* = Haye Park Woods and road back to Ludlow; *L.* = Ludlow (chiefly Castle grounds).

HYMENOMYCETES

Armillaria mellea (Vahl) Fr., rhizomorphs only, *H.*, *L.*
Lepiota amianthina (Scop.) Fr., *H.*
Tricholoma gambosum Fr., *H.*
Mycena galericulata (Scop.) Fr., *W.*, ammoniaca Fr., *W.*, sanguinolenta (A. & S.) Fr., *H.*
Omphalia umbellifera (Linn.) Fr., *W.*
Marasmius oreades (Bolt.) Fr., *W.*, esculentus (Wulf.) Karst., *B.*, *W.*, dryophilus (Bull.) Karst., *B.*, *H.*
Androsaceus androsaceus (Linn.) Pat., *B.*
Panus stipticus (Bull.) Fr., *W.*, *H.*
Dictyolus muscigenus (Bull.) Quél., *B.*
Pluteus cervinus (Schaeff.) Fr., *H.*
Nolanea proletaria Fr., *B.*, *W.*, cetrata (Fr.) Schroet., *B.*
Pholiota praecox (Pers.) Fr., *B.*, mutabilis (Schaeff.) Fr., *W.*, *H.*
Galera hypnorum (Schrank) Fr., *B.*, *W.*, *H.*, and var. bryorum (Pers.) Fr., *H.*, rubiginosa (Pers.) Fr., *B.*
Flammula alnicola Fr., *W.*, conissans Fr., *B.*
Stropharia semiglobata (Batsch) Fr., *B.*, *W.*
Hypholoma fasciculare (Huds.) Fr., *B.*, *H.*, radicosum Lange, *B.*
Psathyrella disseminata (Pers.) Fr., *H.*
Panaeolus campanulatus (Linn.) Fr., *W.*

Coprinus plicatilis (Curt.) Fr., *W.*
Boletus erythropus (Pers.) Quél., *B.*
Polyporus brumalis (Pers.) Fr., *B.*, squamosus (Huds.) Fr., *Stanton Lacy*, betulinus (Bull.) Fr., *H.*, on oak, *B.*
Fomes Ribis (Schum.) Fr., *W.*, annosus Fr., *B.*, *W.*
Ganoderma applanatum (Pers.) Pat., *W.*
Polystictus versicolor (Linn.) Fr., *B.*, *W.*, *H.*, abietinus (Dicks.) Fr., *B.*
Irpex obliquus (Schrad.) Fr., *W.*
Trametes mollis (Sommerf.) Fr., *H.*
Daedalea quercina (Linn.) Fr., *H.*
Radulum quercinum Fr., *B.*
Hypochnus fumosus Fr., *B.*, *H.*
Stereum spadiceum Fr., *B.*, *H.*, rugosum (Pers.) Fr., *B.*, sanguinolentum (A. & S.) Fr., *B.*, hirsutum (Willd.) Fr., *B.*, *W.*, *H.*
Hymenochaete rubiginosa (Dicks.) Lév., *H.*
Corticium Sambuci (Pers.) Fr., *H.*, subcoronatum v. Hoehn. & Litsch., *B.*, botryosum Bres., *B.*, *H.*, confine Bourd. & Galz., *H.*, porosum B. & C., *W.*, praetermissum (Karst.) Bres., *W.*, *H.*
Peniophora glebulosa (Fr.) Bres., *B.*, accedens Bourd. & Galz., *B.*, sanguinea (Fr.) Bres., *B.*, *H.*, velutina (DC.) Cooke, *B.*, setigera (Fr.) Bres., *H.*, hydnoides Cooke & Mass., *B.*, *H.*, gigantea (Fr.) Mass., *B.*, quercina (Pers.) Cooke, *B.*, *H.*, sublaevis (Bres.) v. Hoehn. & Litsch., *H.*
Tulasnella allantospora Wakef. & Pears., *B.*
Auricularia mesenterica (Dicks.) Fr., *W.*, auricula-Judae (Linn.) Schroet., *W.*
Exidia glandulosa (Bull.) Fr., *B.*, *H.*
Dacryomyces deliquescens (Bull.) Duby, *B.*, *H.*
Sebacina subhyalina Pears., *B.*
Heterochaetella crystallina Bourd., *B.*
Tremella foliacea (Pers.) Fr., *B.*, tubercularia Berk., *H.*, encephala (Willd.) Quél., *B.*

GASTEROMYCETES

Phallus impudicus (Linn.) Pers., *W.*
Bovista plumbea Fr., *B.*
Crucibulum vulgare Tul., *W.*

UREDINALES

Uromyces Ficariae (Schum.) Lév., *W.*, *L.*, Orobi (Pers.) Plowr., *W.*, Alchemillae (Pers.) Lév., *B.*, Acetosae Schroet., *B.*, Poae Rabenh., on *Poa* and *Ranunculus*, *L.*
Puccinia Violae (Schum.) DC., *W.*, *H.*, Malvacearum Mont., *L.*, Aegopodii (Schum.) Mart., *B.*, Chondrillae Corda, on *Lactuca muralis*, *H.*, Lampsanae (Schulz.) Fuck., *H.*, Betonicae (A. & S.) DC., *B.*, obscura Schroet., *B.*, Caricis (Schum.) Rebent. (aecidium), *B.*, *W.*, *H.*, Pringsheimiana Kleb., *W.*, coronata Corda, *B.*, Arrhenatheri (Kleb.) Eriks., *H.*, Phalaridis Plowr., *H.*, Poarum Niels. (aecidium), *H.*, mirabilissima Peck, *B.*
Triphragmium Ulmariae (Schum.) Link, *H.*
Phragmidium mucronatum (Pers.) Schlecht., *H.*
Kuehneola albida (Kuehn.) Magn., *W.*
Melampsora Rostrupii Wagn., aecidium, on *Mercurialis*, *B.*
Melampsorella Symphyti (DC.) Bubák, *B.*

USTILAGINALES

Entyloma Ranunculi (Bon.) Schroet., *H.*, *L.*
Ustilago striaeformis (West.) v. Niessl, *H.*, violacea (Pers.) Rouss., *H.*

PYRENOMYCETES

Capnodium salicinum Mont. on Willow, *L.*
Podosphaera Oxyacanthae (DC.) de Bary, *H.*
Erysiphe graminis DC., *B.*, *H.*
Nectria cinnabarina (Tode) Fr., *B.*
Hypocrea pulvinata Fuck., on *Polyporus betulinus*, *W.*
Epichloe typhina (Pers.) Tul., *W.*
Cordyceps gracilis Mont. & Dur., *B.*, *W.*, Forquignonii Quél., *B.*
Venturia Rumicis (Desm.) Wint., *B.*
Leptosphaeria acuta (Moug. & Nestl.) Karst., *B.*
Stigmatea Robertiani Fr., *W.*, *H.*, *L.*
Melanconis stilbostoma (Fr.) Tul., *W.*
Diaporthe leiphaemia (Fr.) Sacc., *H.*
Daldinia concentrica (Bolt.) Ces. & de Not., *B.*
Xylaria Hypoxylon (Linn.) Grev., *H.*
Phyllachora graminis (Pers.) Fuck., *W.*
Endodothella Junci (Fr.) Theiss. & Syd., *B.*
Plowrightia ribesia (Pers.) Sacc., *W.*
Rhopographus filicinus (Fr.) Nits., *B.*
Ctenomyces serratus Eidam, on pupa, *B.*

DISCOMYCETES

Ciliaria scutellata (Linn.) Quél., *L.*
Stromatinia baccarum (Schroet.) Boud., *W.*, *H.*
Dasyscypha virginea (Batsch) Fuck., *H.*
Trichoscypha calycina (Schum.) Karst., *B.*
Hyaloscypha hyalina (Pers.) Boud., *B.*
Micropodia pteridina (Karst.) Boud., *H.*
Mollisia cinerea (Batsch) Karst., *B.*, *H.*
Stegia Ilicis Fr., *W.*
Colpoma quercinum (Pers.) Wallr., *W.*
Rhytisma acerinum (Pers.) Fr., *B.*

PHYCOMYCETES

Plasmopara pygmaea (Ung.) Schroet., on *Ranunculus Ficaria*, *B.*, *L.*
Peronospora parasitica (Pers.) Tul., *H.*, Trifoliorum de Bary, *H.*
Mucor Mucedo (Linn.) Bref., on dead pupa, *B.*

DEUTEROMYCETES

Phyllosticta hedericola Dur. & Mont., *B.*
Dilophospora Alopecuri Fr., *W.*
Oidium alphitoides Griff. & Maubl., *H.*
Mastigosporium album Riess, var. muticum Sacc., on *Dactylis*, *B.*, *W.*, *L.*
Ovularia obliqua (Cooke) Oud., *B.*, *H.*
Botrytis cinerea Pers., on *Aesculus*, *B.*
Trichoderma viride Fr., *H.*
Bispora monilioides Corda, *H.*
Beauveria densa (Link) Vuill., on pupa, *B.*
Isaria farinosa (Holmsk.) Fr., *B.*, *W.*, *H.*
Verticicladium apicale (B. & Br.) Sacc., on an effete insect gall on a fallen oak leaf, *H.*
Sporocybe Azaleae Peck, *B.*

MYCETOZOA

Ceratiomyxa fruticulosa Macbr., *B.*, *H.*
Fuligo septica Gmel., *W.*, *H.*
Comatricha nigra Schroet., *W.*
Cribraria rufa Rost., *B.*, aurantiaca Schrad., *B.*
Tubifera ferruginosa Gmel., *H.*
Reticularia Lycoperdon Bull., *B.*, *H.*
Lycogala epidendrum Fr., *B.*, *W.*, *H.*
Trichia decipiens Macbr., *H.*, persimilis Karst., *B.*, *H.*, affinis de Bary, *B.*, *H.*
Hemitrichia leiotricha Lister, *H.*
Arcyria denudata Wettst., *H.*, pomiformis Rost., *H.*, incarnata Pers., *W.*, *H.*

LICHENS OF THE LUDLOW DISTRICT

By H. H. KNIGHT

On the first day's excursion to Brown Clee Hill we found *Cetraria chlorophylla* in some quantity growing on trees. Here also on walls we noticed *Lecidea lucida* with apothecia.

A favourite habitat for *Lecanora muralis* is on bridges, and it was seen on the bridge over the Teme below the Castle. In the woods beyond the bridge *Thelotrema lepadinum* and *Lecanactis abietina* were common on trees, the latter only with spermagones.

In Haye Park Woods *Parmelia ambigua* was growing finely on beech trees. This was also noted sparingly near Burwarton. Haye Park is one of the few localities given in the British Museum Monograph for *Stenocybe byssacea*, and Mr D. A. Jones was successful in finding it on alders.

After the rest of the party had left, I went with Mr Jones to Titterstone Clee Hill. This hill is covered on the top with basalt, and is a well-known locality for the moss *Grimmia incurva*. Here we saw *Stereocaulon*, and on the hard rocks several species of *Lecanora* and *Lecidea*; also *Bacidia flavovirescens*.

In the following list: *B.* = Burwarton and Brown Clee Hill. *L.* = Ludlow and the woods near it on the right bank of the Teme. *H.* = Haye Park Woods and Mary Knowl Valley, both in Herefordshire. *T.* = Titterstone Clee Hill.

Chaenotheca melanophaea Zwackh., *B.*
Calicium hyperellum Ach., *B.*
Stenocybe byssacea Nyl., *H.*
Leptogium turgidum Cromb., *L.*
Peltigera canina Willd., *L.*
P. rufescens Hoffm., *L.*
P. polydactyla Hoffm., *H.*
P. horizontalis Hoffm., *H.*
Parmelia physodes Ach., *B.*, *H.*
P. perlata Ach., *B.*
P. caperata Ach., *H.*
P. subaurifera Nyl., *L.*
P. saxatilis Ach., *B.*
and f. furfuracea Schaer., *B.*
P. sulcata Tayl., *B.*
P. ambigua Ach., *B.*, *H.*
P. revoluta Floerke, *H.*
P. fuliginosa Nyl., *B.*, *T.*
and var. laetevirens Nyl., *B.*
Cetraria glauca Ach., *B.*
C. chlorophylla Wain., *B.*
Evernia prunastri Ach., *B.*, *H.*

Ramalina fastigiata Ach., *L.*
R. farinacea Ach., *L.*
Usnea florida Web. var. hirta Ach., *B.*
Xanthoria parietina Th. Fr., *B.*
X. polycarpa Oliv., *L.*
X. lychnea Th. Fr., *B.*, *L.*
Placodium rupestre Branth. & Rostr., *L.*
Candelariella vitellina Muell.-Arg., *B.*
Physcia pulverulenta Nyl., *L.*
P. grisea Zahlbr., *L.*
P. erosa Leight., *B.*, *L.*
Rinodina roboris Arn., *H.*
Lecanora muralis Schaer., *L.*
L. subfusca Ach., *B.*, *L.*
L. campestris B. de Lesd., *B.*
L. pallida Schaer., *H.*
L. carpinea Wain., *B.*
L. varia Ach., *B.*, *L.*
L. symmicta Ach., *T.*
L. sulphurea Ach., *T.*
L. polytropa Schaer., *B.*, *T.*
and f. efflorescens Cromb., *T.*
L. badia Ach., *T.*
L. parella Ach., *L.*
Acarospora fuscata Th. Fr., *B.*
Pertusaria globulifera Nyl., *B.*
P. faginea Leight., *B.*, *H.*
P. multipuncta Nyl., *H.*
P. pertusa Dal. Tor. & Sarnth., *B.*, *H.*
P. leioplaca Schaer., *H.*
P. Wulfenii DC., *B.*, *H.*
Thelotrema lepadinum Ach., *L.*
Diploschistes scruposus Norm., *T.*
Baeomyces rufus DC., *B.*, *H.*, *T.*
Stereocaulon condensatum Hoffm., *T.*
S. evolutum Graewe, *T.*
Cladonia sylvatica Hoffm., *H.*, *T.*
C. fimbriata Fr., *B.*
and var. subcornuta Nyl., *B.*
C. furcata Schrad., *T.*
C. rangiformis Hoffm., *T.*
C. caespiticia Floerke, *B.*, *H.*
C. parasitica Hoffm., *H.*
C. digitata Hoffm., *H.*
C. macilenta Hoffm., *H.*
Lecidea ostreata Schaer., *B.*
L. confertula Stirt., *T.*
L. lucida Ach., *B.*
L. quernea Ach., *L.*
L. granulosa Schaer., *T.*
L. parasema Ach., *B*
L. goniophila Schaer., *L.*
L. contigua Fr., *B.*, *T.*
L. sorediza Nyl., *B.*
L. albocoerulescens Nyl., *T.*
L. confluens Ach., *L.*, *T.*
L. plana Nyl., *B.*
L. fuscoatra Ach., *T.*
Biatorina Griffithii Massal., *B.*, *H.*
B. lenticularis Koerb., *L.*
Bilimbia sabuletorum Br. & Rostr., *B.*
B. lignaria Massal., *T.*
Bacidia umbrina Br. & Rostr., *B.*, *T.*
B. flavovirescens Anzi, *T.*
Buellia myriocarpa Mudd, *L.*
Rhizocarpon geographicum DC., *T.*
R. petraeum Massal., *L.*
Lecanactis abietina Koerb., *L.*
Arthonia radiata Ach., *H.*
and var. Swartziana Sydow, *H.*
Opegrapha atra Pers., *L.*
Graphis elegans Ach., *H.*
Arthopyrenia fallax Arn., *B.*, *H.*
Porina carpinea A. Zahlbr., *B.*

THE HASLEMERE FORAY

September 19th–24th, 1932

By E. M. WAKEFIELD

The thirty-sixth Autumn Foray and Annual General Meeting of the Society was held at Haslemere during the week September 19th–24th, 1932. This popular district attracted a large number of members, many of whom arrived at the previous week-end.

Through the courtesy of the Committee of Management of the Haslemere Educational Museum, headquarters were at the Museum, where, in addition to ample space for the display of specimens and for meetings, there were available also books and apparatus, and, above all, the valuable local knowledge of the Curator, Mr E. W. Swanton.

For those who arrived early a foray was arranged on Sunday, September 18th, to the Valewood estate. Pasture land and mixed woods of beech and fir provided considerable variety in the fungi collected. There was unusual abundance of *Boletus parasiticus* growing on *Scleroderma*, and among the less common species found may be mentioned *Lactarius controversus*, *L. spinulosus* and *Gomphidius gracilis*. After a rather showery afternoon the party much enjoyed the hospitality of Mrs Daffarn, who had invited them to tea at Valewood.

The real programme of the week began on Monday, September 19th, when members assembled at the Museum and were entertained to tea by the Haslemere Natural History Society. Dr A. Lyndon, on behalf of the Committee of the Museum and of the Haslemere Natural History Society, extended a cordial welcome to the Society on its third autumn visit to Haslemere. The President, Miss Lister, replied, expressing the pleasure felt by members in visiting again one of the great haunts for mycologists.

The first whole-day excursion of the foray was held on the Tuesday, at Hindhead. By permission of Sir John Leigh, Bart., Hurt Hill Wood, consisting mostly of pine, with chestnut coppice, was explored. The return to Haslemere was made by way of Coombeswell and Inval, where woods and fields were visited by permission of Allen Chandler, Esq., and Miss Ursula Hutchinson. Among the more noteworthy finds of the day were *Eccilia rhodocylix*, *Entoloma griseocyaneum*, *Cordyceps capitata*, and *Asterostroma laxum* Bres., the latter new to Britain.

Miss Ursula Hutchinson very kindly provided tea at Inval, and after tea a pleasant time was spent in inspecting the garden there, and in seeing something of the work of the Inval weavers. Lichenologists were especially interested in seeing samples of the lichens used for dyeing the wool.

On the Tuesday evening, at 8.45 p.m., the Annual General Meeting was held. Prof. W. Brown was elected as President for 1933. Miss Lister and Dr B. Barnes were appointed Vice-Presidents. The other officers remain as before. In place of the three members of Council who were due to retire in rotation, Miss C. A. Cooper, Dr Alex. Smith and Mr W. Wilkins were elected. An invitation from Mr A. W. Bartlett to hold the Autumn Foray in 1933 at Newcastle was accepted.

On Wednesday, September 21st, a start was made at 11.30 a.m. for Henley, Sussex, where Henley Common and the adjacent woods were explored. Among the more interesting finds were *Russula luteotacta*, *Pleurotus atrocaeruleus*, *Flammula limulata*, *Cortinarius myrtillinus*, *Thelephora spiculosa*, and a magnificent group of *Clavaria Botrytis*. In the evening, at 8.45 p.m., Miss Lister delivered her Presidential Address, "Field Notes on Mycetozoa."

The Thursday was unfortunately very wet, and the rain spoilt what would otherwise have been a most enjoyable day in rich hunting-ground. The journey was made by motor-bus to Cocking, and after traversing Manor Farm Down some shelter was obtained in the forests of Singleton and Charlton, permission to explore which had been granted by the Duke of Richmond. These woods consist mostly of beech, with ash and oak. Collecting in the rain was not pleasant, but in spite of difficulties an interesting collection of fungi was brought in at the end of the day. The abundance of *Marasmius alliaceus* in Charlton Forest was a matter of comment, for to many members this species was quite new. Among other good finds in the woods were *Laccaria tortilis*, *Hygrophorus chrysodon*, *Lactarius flavidus*, *Marasmius globularis*, *Eccilia griseorubella*, *Inocybe corydalina*, *I. descissa*, *Clavaria pistillaris*, and a *Tricholoma* which appears to be undescribed. On Manor Farm Down was found *Entoloma excentricum* Bres., also a new British record. In the evening Mr Ramsbottom read a paper on "Fungi as scavengers."

Friday was again very wet, but a party somewhat reduced in numbers braved the weather and set out for Grayswood, where, by permission of W. Geoffrey Jackson, Esq., Prestwick and Frillinghurst Woods were worked. *Gomphidius gracilis* was again found, and *Russula pseudointegra* Arn. & Goris was added to the British list by Mr Pearson. Other good finds were *Cortinarius spilomeus*, *C. uliginosus*, *C. collinitus*, and a number of microfungi.

In addition to the fungi collected during the regular excursions which had been planned, the following list contains also records made by members who were interested in special groups and who made some independent expeditions. In particular mention must be made of the list of Phycomycetes supplied by Dr F. K. Sparrow, Jr., a visitor. He found the pond in the grounds of the Educational Museum a rich locality for these micro-forms, and the result is a list of Phycomycetes such as no previous foray report has contained. Some of

the pathologists of the party visited the gardens at Grayswood Hill, and reported various parasitic fungi, of which may be mentioned a specially fine collection of *Plasmopara viticola* on *Vitis Coignetiae*.

At the close of the meeting hearty thanks were accorded to the landowners who had given permission for their estates to be visited, and to the Committee of the Haslemere Educational Museum and the Haslemere Natural History Society for their hospitality. Mr Rea was accorded a vote of thanks for so kindly lending an admirable series of paintings of fungi which were displayed in frames during the week and were a great help to many of those present. Special thanks were expressed to Mr E. W. Swanton, for the great trouble he had taken in organising the meeting and for his constant kindly assistance. Appreciation was also given to Mrs Swanton and to the Assistant Curator, Miss Waite, who looked after the welfare of the party in many ways, and who by taking over Museum duties had allowed Mr Swanton to accompany the various expeditions and act as guide.

For assistance in compiling the attached list the Secretary is indebted to all members present, and especially to Mr Carleton Rea, Mr Pearson, Mr Ramsbottom, Mr Muskett and Dr Sparrow (Phycomycetes).

Complete List of Species gathered during the Foray

V. = Valewood; *B.* = Blackdown Beech Hangar; *K.* = Hurt Hill Wood and Inval (Hindhead); *H.* = Henley Common and Beech Woods; *C.* = Cocking (Manor Farm Down), Singleton and Charlton Forests; *P.* = Prestwick and Frillinghurst Woods; *G.* = Grayswood Common and Grayswood Hill; *E.* = Pond at Educational Museum, Haslemere.

HYMENOMYCETES

Amanita verna (Lam.) Fr. (= A. virosa Fr.), *K.*, *H.*, *G.*, phalloides (Vaill.) Fr., *K.*, *H.*, *C.*, *G.*, and var. verna (Bull.) Fr., *K.*, porphyria (A. & S.) Fr., *H.*, mappa (Batsch) Fr., *V.*, *K.*, *H.*, *P.*, muscaria (Linn.) Fr., *K.*, pantherina (DC.) Fr., *H.*, *P.*, spissa Fr., *K.*, *H.*, rubescens (Pers.) Fr., *V.*, *K.*, *H.*, *P.*, *G.*

Amanitopsis vaginata (Bull.) Roze, *V.*, *H.*, *P.*, fulva (Schaeff.) W. G. Sm., *V.*, *K.*, *H.*, *G.*, strangulata (Fr.) Roze, *K.*

Armillaria mucida (Schrad.) Fr., *V.*, *K.*, *H.*, *C.*

Lepiota procera (Scop.) Fr., *C.*, clypeolaria (Bull.) Fr., *K.*, *C.*, cristata (A. & S.) Fr., *K.*, *C.*, sistrata Fr., *C.*

Tricholoma sejunctum (Sow.) Fr., *H.*, *C.*, *P.*, resplendens Fr., *K.*, *H.*, fulvum (DC.) Fr., *C.*, albobrunneum (Pers.) Fr., *P.*, rutilans (Schaeff.) Fr., *V.*, *K.*, *C.*, terreum (Schaeff.) Fr., *V.*, *K.*, *H.*, *C.*, *P.*, argyraceum (Bull.) Fr., *K.*, *C.*, cuneifolium Fr., *C.*, sulphureum (Bull.) Fr., *K.*, *C.*, panaeolum Fr., *C.*, grammopodium (Bull.) Fr., *C.*, melaleucum (Pers.) Fr., *H.*, *C.*

Clitocybe clavipes (Pers.) Fr., *K.*, *H.*, aurantiaca (Wulf.) Studer, *V.*, *K.*, *H.*, maxima (Fl. Wett.) Fr., *C.*, infundibuliformis (Schaeff.) Fr., *V.*, *H.*

Laccaria laccata (Scop.) B. & Br., *V.*, *K.*, *H.*, *P.*, *G.*, and var. amethystina (Vaill.) B. & Br., *K.*, *H.*, tortilis (Bolt.) Boud., *C.*

Collybia radicata (Relh.) Berk., *K.*, *H.*, *C.*, *G.*, platyphylla (Pers.) Fr., *B.*, *K.*, *H.*, *G.*, fusipes (Bull.) Berk., *V.*, *C.*, *P.*, maculata (A. & S.) Fr., *K.*, *H.*, tuberosa (Bull.) Fr., *P.*, rancida Fr., *K.*, atrata Fr., *P.*

Mycena pelianthina Fr., *H.*, *C.*, aurantiomarginata Fr., *H.*, rubromarginata Fr., *K.*, pura (Pers.) Fr., *V.*, *K.*, lactea (Pers.) Fr., *C.*, galericulata (Scop.) Fr., *K.*, *H.*, *C.*, polygramma (Bull.) Fr., *C.*, *P.*, alcalina Fr., *K.*, ammoniaca Fr., *K.*, *P.*, Iris Berk., *K.*, sanguinolenta (A. & S.) Fr., *V.*, *K.*, *C.*, crocata (Schrad.) Fr., *C.*, galopus (Pers.) Fr., *K.*, *H.*, *C.*, *P.*, and var. nigra Fl. Dan., *K.*, *C.*, *V.*, tenerrima Berk., *K.*

Omphalia muralis (Sow.) Fr., *H.*, umbellifera (Linn.) Fr. var. pallida Cooke, *K.*, fibula (Bull.) Fr., *V.*, *K.*, *C.*, and var. Swartzii Fr., *V.*, integrella (Pers.) Fr., *K.*, *H.*

Pleurotus atrocaeruleus Fr., *H.*

Hygrophorus chrysodon Fr., *C.*, eburneus (Bull.) Fr., *H.*, pratensis (Pers.) Fr. var. cinereus Fr., *V.*, ceraceus (Wulf.) Fr., *C.*, coccineus (Schaeff.) Fr., *V.*, *K.*, miniatus Fr., *V.*, Reai Maire, *K.*, conicus (Scop.) Fr., *C.*, *H.*, psittacinus (Schaeff.) Fr., *C.*, *P.*

Lactarius torminosus (Schaeff.) Fr., *C.*, *P.*, *G.*, turpis (Weinm.) Fr., *K.*, controversus (Pers.) Fr., *V.*, zonarius (Bull.) Fr., *P.*, blennius Fr., *V.*, *K.*, *H.*, flavidus Boud., *C.*, pyrogalus (Bull.) Fr., *C.*, chrysorheus Fr., *P.*, piperatus (Scop.) Fr., *C.*, vellereus Fr., *H.*, *C.*, quietus Fr., *V.*, *K.*, *H.*, *C.*, *G.*, theiogalus (Fr.) Plowr., *K.*, *H.*, vietus Fr., *K.*, *P.*, rufus (Scop.) Fr., *K.*, *H.*, glyciosmus Fr., *K.*, fuliginosus Fr., *K.*, *H.*, *C.*, *P.*, picinus Fr., *H.*, spinulosus Quél., *V.*, volemus Fr., *K.*, *P.*, *G.*, serifluus (DC.) Fr., *V.*, *K.*, *C.*, *P.*, mitissimus Fr., *P.*, subdulcis (Pers.) Fr., *V.*, *K.*, *H.*, cimicarius (Batsch) Cooke, *K.*, *P.*, obnubilus (Lasch) Fr., *V.*, *K.*

Russula chloroides (Krombh.) Bres., *V.*, *K.*, *C.*, nigricans (Bull.) Fr., *V.*, *K.*, *H.*, *C.*, *P.*, adusta (Pers.) Fr., *V.*, *K.*, *H.*, virescens (Schaeff.) Fr., *H.*, lepida Fr., *K.*, azurea Bres., *V.*, cyanoxantha (Schaeff.) Fr., *V.*, *K.*, *H.*, *C.*, furcata (Pers.) Fr., *K.*, *H.*, *P.*, *G.*, heterophylla Fr., *H.*, foetens (Pers.) Fr., *V.*, *H.*, *P.*, consobrina Fr. var. sororia (Larb.) Fr., *V.*, *K.*, *C.*, ochroleuca (Pers.) Fr., *V.*, *K.*, fellea Fr., *V.*, *K.*, *H.*, subfoetens W. G. Sm., *H.*, drimeia Cooke, *K.*, *C.*, fragilis (Pers.) Fr., *V.*, *C.*, *P.*, and var. fallax (Schaeff.) Mass., *K.*, violacea Quél., *K.*, emetica (Schaeff.) Fr., *V.*, *K.*, *H.*, luteotacta Rea, *H.*, atropurpurea (Krombh.) Maire, *K.*, *H.*, *G.*, and var. depallens (Cooke) Maire, *V.*, *K.*, *H.*, Romellii Maire, *H.*, xerampelina (Schaeff.) Fr., *K.*, *C.*, *P.*, and var. fusca (Quél.) *H.*, puellaris Fr., *V.*, *K.*, *C.*, nitida (Pers.) Fr., *K.*, maculata Quél., *K.*, aurata (With.) Fr., *H.*, *P.*, vesca Fr., *K.*, *P.*, punctata (Gill.) Maire, *K.*, lutea (Huds.) Fr. *V.*, *P.*, and var. armeniaca (Cooke) Rea, *V.*, *K.*, pseudointegra Arn. & Goris, *P.**

Cantharellus cibarius Fr., *K.*, *H.*, *P.*, tubaeformis Fr., *K.*, cinereus (Pers.) Fr., *K.*, *H.*

Nyctalis parasitica (Bull.) Fr., *K.*, *G.*, asterophora Fr., *P.*

Marasmius peronatus (Bolt.) Fr., *K.*, *P.*, globularis Fr., *C.*, erythropus (Pers.) Fr., *V.*, *K.*, hariolorum (DC.) Quél., *C.*, dryophilus (Bull.) Karst., *V.*, *K.*, *C.*, ramealis (Bull.) Fr., *K.*, *C.*, alliaceus (Jacq.) Fr., *C.*

Androsaceus androsaceus (Linn.) Pat., *V.*, *K.*, *C.*, rotula (Scop.) Pat., *K.*, epiphyllus (Fr.) Pat., *V.*

Panus stipticus (Bull.) Fr., *K.*, *P.*

Pluteus cervinus (Schaeff.) Fr., *K.*, *H.*, *C.*, nanus (Pers.) Fr., *H.*, *C.*

Entoloma lividum (Bull.) Fr., *H.*, porphyrophaeum Fr., *V.*, *K.*, repandum (Bull.) Fr., *C.*, griseocyaneum Fr., *K.*, rhodopolium Fr., *V.*, *C.*, sericeum (Bull.) Fr., *K.*, nidorosum Fr., *C.*, *P.*, excentricum Bres., *C.**

Nolanea proletaria Fr., *K.*, *H.*, *P.*, papillata Bres., *K.*, *H.*

Leptonia lampropus Fr., *V.*, serrulata (Pers.) Fr., *V.*, *C.*, sericella (Fr.) Quél., *P.*

Eccilia griseorubella (Lasch) Fr., *C.*, rhodocylix (Lasch) Fr., *V.*

Clitopilus prunulus (Scop.) Fr., *V.*, *H.*, *P.*

Claudopus variabilis (Pers.) W. G. Sm., *K.*, *H.*

Paxillus involutus (Batsch) Fr., *V.*, *K.*

* New to Britain.

Pholiota radicosa (Bull.) Fr., *P.*, spectabilis Fr., *H.*, mutabilis (Schaeff.) Fr., *H.*, *C.*, flammans Fr., *G.*
Hebeloma fastibile Fr., *K.*, versipelle Fr., *V.*, mesophaeum Fr., *K.*, crustuliniforme (Bull.) Fr., *C.*
Inocybe pyriodora (Pers.) Fr., *C.*, rimosa (Bull.) Fr., *V.*, *H.*, *C.*, tomentosa (Jungh.) Quél., *H.*, corydalina Quél., *C.*, geophylla (Sow.) Fr., *H.*, *C.*, and var. lilacina Fr., *K.*, descissa Fr., *K.*, *C.*, cervicolor (Pers.) Quél., *V.*, lucifuga Fr., *H.*, obscura (Pers.) Fr., *H.*, hystrix Fr., *K.*, relicina Fr., *K.*, cincinnata Fr., *P.*, fastigiata (Schaeff.) Fr., *H.*, maculata Boud., *H.*
Astrosporina asterospora (Quél.) Rea, *V.*, *H.*, lanuginosa (Bull.) Schroet., *H.*, scabella (Fr.) Schroet., *C.*, petiginosa (Fr.) Rea, *H.*, umbrina Bres., *H.*
Galera hypnorum (Schrank) Fr., *V.*, *K.*, *H.*
Bolbitius titubans (Bull.) Fr., *K.*
Naucoria cucumis (Pers.) Fr., *H.*
Tubaria furfuracea (Pers.) W. G. Sm., *H.*
Flammula sapinea Fr., *V.*, *K.*, *H.*, *P.*, *G.*, limulata Fr., *H.*, ochrochlora Fr., *H.*, *P.*
Cortinarius (Phlegmacium) varius (Schaeff.) Fr., *P.*, purpurascens Fr., *H.*, *P.*, (Myxacium) collinitus (Sow.) Fr., *C.*, *P.*, elatior Fr., *V.*, *K.*, *H.*, *P.*, delibutus Fr., *H.*, (Inoloma) bolaris (Pers.) Fr., *B.*, *K.*, *H.*, (Dermocybe) caninus Fr., *K.*, anomalus Fr., *H.*, lepidopus Cooke, *K.*, myrtillinus Fr., *H.*, spilomeus Fr., *P.*, phoeniceus (Bull.) Maire, *H.*, semisanguineus (Brig.) Maire, *H.*, cinnabarinus Fr., *H.*, cinnamomeus (Linn.) Fr., *K.*, *P.*, uliginosus Berk., *P.*, (Telamonia) torvus Fr., *H.*, *P.*, armillatus Fr., *K.*, *H.*, hinnuleus (Sow.) Fr., *K.*, *H.*, *P.*, gentilis Fr., *H.*, *P.*, flexipes Fr., *H.*, incisus (Pers.) Fr., *P.*, hemitrichus Fr., *K.*, *H.*, rigidus (Scop.) Fr., *V.*, *K.*, (Hydrocybe) castaneus (Bull.) Fr., *K.*, *H.*, dolabratus Fr., *H.*, decipiens (Pers.) Fr., *K.*, acutus (Pers.) Fr., *V.*, *H.*
Crepidotus mollis (Schaeff.) Fr., *C.*
Psalliota campestris (Linn.) Fr., *V.*, xanthoderma Genev., *C.*, and var. lepiotoides Maire, *C.*
Stropharia aeruginosa (Curt.) Fr., *H.*, coronilla (Bull.) Fr., *C.*, semiglobata (Batsch) Fr., *V.*, *K.*
Hypholoma fasciculare (Huds.) Fr., *K.*, elaeodes Fr., *K.*, velutinum (Pers.) Fr., *V.*, *K.*, *H.*, *P.*, appendiculatum (Bull.) Fr., *H.*, *C.*, leucotephrum B. & Br., *C.*, hydrophilum (Bull.) Fr., *K.*, *H.*
Psilocybe ericaea (Pers.) Fr., *C.*, uda (Pers.) Fr., *K.*, semilanceata Fr., *V.*, *K.*
Psathyra fibrillosa (Pers.) Fr., *V.*, *K.*, *H.*
Panaeolus sphinctrinus Fr., *K.*, campanulatus (Linn.) Fr., *V.*, *K.*, *H.*, papilionaceus (Bull.) Fr., *V.*
Coprinus comatus (Fl. Dan.) Fr., *K.*, atramentarius (Bull.) Fr., *H.*, micaceus (Bull.) Fr., *H.*, niveus (Pers.) Fr., *V.*, lagopus Fr., *V.*, *H.*
Gomphidius glutinosus (Schaeff.) Fr., *V.*, viscidus (Linn.) Fr., *V.*, gracilis B. & Br., *V.*, *P.*
Boletus castaneus (Bull.) Fr., *H.*, felleus (Bull.) Fr., *V.*, *K.*, porphyrosporus Fr., *K.*, luteus (Linn.) Fr., *V.*, *K.*, elegans (Schum.) Fr., *V.*, *H.*, *P.*, viscidus (Linn.) Fr., *H.*, granulatus (Linn.) Fr., *V.*, badius Fr., *K.*, *H.*, bovinus (Linn.) Fr., *V.*, *K.*, *H.*, piperatus (Bull.) Fr., *H.*, variegatus (Sw.) Fr., *K.*, *H.*, chrysenteron (Bull.) Fr., *K.*, *H.*, subtomentosus (Linn.) Fr., *K.*, *H.*, *G.*, versicolor Rost., *V.*, *K.*, pruinatus Fr., *K.*, parasiticus (Bull.) Fr., *V.*, *K.*, *H.*, edulis (Bull.) Fr., *V.*, *K.*, *H.*, *P.*, *G.*, pinicola (Vitt.) Rea, *H.*, reticulatus (Schaeff.) Boud., *V.*, *H.*, vaccinus Fr., *K.*, candicans Fr., *V.*, erythropus (Pers.) Quél., *V.*, *K.*, *H.*, duriusculus Schulz., *V.*, *K.*, *H.*, versipellis Fr., *K.*, *P.*, *G.*, scaber (Bull.) Fr., *V.*, *K.*, *P.*
Polyporus perennis (Linn.) Fr., *K.*, Schweinitzii Fr., *V.*, *K.*, giganteus (Pers.) Fr., *H.*, betulinus (Bull.) Fr., *V.*, adustus (Willd.) Fr., *P.*, fragilis Fr., *K.*, stipticus (Pers.) Fr., on living Spruce, *V.*, caesius (Schrad.) Fr., *K.*, *H.*, *C.*
Fomes annosus Fr., *V.*, ferruginosus (Schrad.) Mass., *C.*
Ganoderma applanatum (Pers.) Pat., *H.*, *C.*, resinaceum Boud., *H.*

Poria xantha Lind, *K.*
Polystictus versicolor (Linn.) Fr., *K.*, *P.*, abietinus (Dicks.) Fr., *K.*
Irpex obliquus (Schrad.) Fr., *H.*
Lenzites betulina (Linn.) Fr., *P.*
Trametes gibbosa (Pers.) Fr., *P.*, rubescens (A. & S.) Fr., *B.*, *H.*
Daedalea biennis (Bull.) Quél., *K.*, *P.*, quercina (Linn.) Fr., *V.*
Merulius tremellosus (Schrad.) Fr., *B.*, Corium (Pers.) Fr., *H.*, rufus (Pers.) Fr., *K.*
Coniophora arida Fr., *K.*
Fistulina hepatica (Huds.) Fr., *V.*, *K.*
Hydnum repandum (Linn.) Fr., *K.*, *P.*, and var. rufescens (Pers.) Fr., *K.*, auriscalpium (Linn.) Fr., *K.*
Grandinia granulosa Fr., *K.*
Craterellus cornucopioides (Linn.) Fr., *K.*, *H.*, *C.*, *P.*, sinuosus Fr., *K.*, crispus (Sow.) Fr., *K.*
Thelephora terrestris (Ehrh.) Fr., *K.*, *H.*, anthocephala (Bull.) Fr., *K.*, spiculosa (Fr.) Burt, *H.*
Sparassis crispa (Wulf.) Fr., *H.*
Stereum rugosum (Pers.) Fr., *H.*, *P.*, sanguinolentum (A. & S.) Fr., *K.*, hirsutum (Willd.) Fr., *V.*, *K.*, *P.*, purpureum (Pers.) Fr., *K.*, *P.* (on birch).
Corticium botryosum Bres., *K.*, *C.*, subcoronatum v. Hoehn. & Litsch., *K.*, porosum B. & C., *H.*, *C.*, praetermissum (Karst.) Bres., *H.*
Peniophora pallidula Bres., *K.*, setigera (Fr.) Bres., *H.*, hydnoides C. & M., *H.*, *C.*, quercina (Pers.) Cooke, *H.*
Asterostroma laxum Bres., *K.**
Clavaria cristata (Holmsk.) Fr., *K.*, *H.*, *C.*, cinerea (Bull.) Fr., *C.*, amethystina (Batt.) Fr., *H.*, rugosa (Bull.) Fr., *K.*, *H.*, Kunzei Fr., *K.*, *C.*, corniculata (Schaeff.) Fr., *K.*, botrytis (Pers.) Fr., *H.*, stricta (Pers.) Fr., *H.*, fusiformis (Sow.) Fr., *K.*, *H.*, inaequalis (Mull.) Fr., *H.*, acuta (Sow.) Fr., *K.*, pistillaris (Linn.) Fr., *C.*
Pistillaria quisquiliaris Fr., *P.*
Tremella lutescens Pers., *P.*
Exidia glandulosa (Bull.) Fr., *H.*
Tremellodon gelatinosum (Scop.) Pers., *K.*
Sebacina incrustans (Pers.) Tul., *C.*
Dacryomyces deliquescens (Bull.) Duby, *K.*, *P.*
Femsjonia luteoalba Fr., *H.*, *P.*
Calocera viscosa (Pers.) Fr., *K.*, cornea (Batsch) Fr., *P.*

GASTEROMYCETES

Cynophallus caninus (Huds.) Fr., *V.*, *K.*, *H.*
Phallus impudicus (Linn.) Pers., *V.*, *K.*, *G.*
Lycoperdon caelatum (Bull.) Fr., *C.*, saccatum (Vahl) Fr., *H.*, depressum Bon., *V.*, umbrinum Pers., *V.*, *H.*, perlatum Pers., *H.*, pyriforme (Schaeff.) Pers., *C.*, *G.*
Geaster fimbriatus Fr., *C.*
Cyathus striatus (Huds.) Pers., *H.*, *P.*
Crucibulum vulgare Tul., *K.*
Scleroderma aurantium Pers., *V.*, *K.*, *G.*, verrucosum (Vaill.) Pers., *V.*, *K.*

UREDINALES

Puccinia Violae (Schum.) DC., *P.*, Epilobii DC., *K.*, Saniculae Grev., *P.*, Lampsanae (Schultz) Fuck., *H.*, Menthae Pers., *H.*, Pruni-spinosae Pers., *H.*, mirabilissima Peck, *G.*
Xenodochus carbonarius Schlecht., *C.*

* New to Britain.

Phragmidium violaceum (Schultz) Wint., *P.*, Rubi-Idaei (Pers.) Karst., *H.*, mucronatum Schlecht., on cultivated rose, *P.*
Kuehneola albida Magn., *H.*, *P.*
Coleosporium Euphrasiae (Schum.) Wint., *H.*
Pucciniastrum Epilobii (Pers.) Otth, *P.*, Vacciniorum (Link) Diet., *K.*
Melampsora Euphorbiae Cast., on *Euphorbia amygdalina*, *P.*, Hypericorum (DC.) Schroet., on *Hypericum Androsaemum*, *P.*

USTILAGINALES

Ustilago Scabiosae (Sow.) Wint., *P.*
Sphacelotheca Hydropiperidis (Schum.) de Bary, *V.*, *H.*
Entyloma Calendulae (Oud.) de Bary, *P.*

PYRENOMYCETES

Sphaerotheca pannosa (Wallr.) Lév., *P.*, Humuli (DC.) Burr., on *Arctium*, *H.*
Claviceps microcephala (Wallr.) Tul., *K.*
Cordyceps militaris (Linn.) Fr., *V.*, *K.*, *P.*, capitata (Holmsk.) Link, *K.*, *H.*
Laestadia Buxi (Fuck.) Sacc., pycnidial stage on *Buxus*, *G.*
Didymella applanata (Niessl) Sacc., on raspberry, *Haslemere.*
Ustulina vulgaris Tul., *C.*
Hypoxylon coccineum Bull., *V.*
Xylaria Hypoxylon (Linn.) Grev., *K.*, polymorpha (Pers.) Grev., *K.*, carpophila (Pers.) Fr., *G.*

HYSTERIALES

Lophodermium Pinastri (Schrad.) Chev., *K.*

TUBERALES

Elaphomyces granulatus Fr., *H.*, *K.*

DISCOMYCETES

Helvella lacunosa Afz., *K.*, *H.*
Leptopodia elastica (Bull.) Boud., *K.*, *H.*, *C.*
Macropodia macropus (Pers.) Fuck., *K.*, *H.*, *C.*
Rhizina inflata (Schaeff.) Karst., *K.*, *H.*
Galactinia succosa (Berk.) Sacc., *C.*
Otidea onotica (Pers.) Fuck., *H.*, leporina (Batsch) Fuck., *H.*
Peziza aurantia Pers., *K.*, *P.*
Lachnea hemisphaerica (Wigg.) Gill., *H.*
Ciliaria scutellata (Linn.) Quél., *H.*
Coprobia granulata (Bull.) Boud., *V.*
Microglossum viride (Pers.) Gill., *H.*
Leotia lubrica (Scop.) Pers., *K.*, *H.*
Cudoniella acicularis (Bull.) Schroet., *H.*
Coryne sarcoides (Jacq.) Tul., *P.*
Bulgaria inquinans (Pers.) Fr., *K.*
Phialea firma (Pers.) Gill., *K.*
Chlorosplenium aeruginosum (Oeder.) de Not., on beech and birch, *H.*, *C.*, *P.*
Dasyscypha virginea (Batsch) Fuck., *K.*
Mollisia cinerea (Batsch) Karst., *K.*, *H.*
Stegia Ilicis Fr., *V.*, *K.*, *H.*

PHYCOMYCETES

Chytridium Schenkii (Dang.) Scherffel, parasitic in *Oedogonium* sp. (?), *E.*, inflatum Sparr., parasitic in *Oedogonium*, *E.*, chaetophilum Scherffel, saprophytic on pollen of *Typha* used as bait, *E.*
Rhizophidium fusus (Zopf) Fischer, parasitic in *Synedra* sp. (?), *E.*

Podochytrium clavatum Pfitzer, parasitic in (?) *Fragillaria*, *E.*
Harpochytrium Hedinii Wille, on *Oedogonium*, *E.*
Entophlyctis Cienkowskiana (Zopf) Fischer, parasitic in *Oedogonium* sp., *E.*
Cladochytrium Nowakowskii Sparr., saprophytic in submerged grass leaf, *E.*
Saprolegnia diclina Humphrey, on hemp seed used as bait, *E.*
Achlya colorata Prings., on hemp seed used as bait, *E.*
Monoblepharis ovigera Lagerh., *E.*
Gonapodya prolifera (Cornu) Fischer, on ash twig used as bait, *E.*
Rhipidium americanum Thaxter, saprophytic on twig of oak, *E.*
Sapromyces Reinschii (Reinsch) Fritsch, on twig of ash used as bait, *E.*
Pythiomorpha gonapodioides Peterson, on twig of ash used as bait, *E.*
Plasmopara nivea (Ung.) Schroet., on *Aegopodium*, *H.*, viticola (Berk. & Curt.) Berl. & de Toni, on *Vitis Coignetiae*, *G.*

DEUTEROMYCETES

Septoria chrysanthemella Cav., *G.*, Paeoniae West., *G.*, Rubi West., *P.*
Coniothyrium concentricum (Desm.) Sacc., on *Yucca*, *G.*
Oidium alphitoides Griff. & Maubl., *K.*, *P.*
Ovularia obliqua (Cooke) Oud., *P.*
Botrytis cinerea Pers., on *Rhododendron*, *K.*, on *Lilium* spp. and Paeony, *G.*
Amblyosporium Botrytis Fres., *H.*, *P.*
Trichoderma viride Pers., *V.*
Rhinotrichum Thwaitesii B. & Br., *V.*, *K.*
Sepedonium chrysospermum (Bull.) Fr., *V.*, *K.*, *P.*
Trichothecium roseum (Pers.) Link, *V.*
Ramularia lactea (Desm.) Sacc., *P.*, *G.*, Tulasnei Sacc., *P.*, sambucina Sacc., *H.*, Taraxaci Karst., *H.*, Primulae Thuem., *P.*, *G.*
Bispora monilioides Corda, *V.*
Isaria farinosa (Dicks.) Fr., *V.*, *P.*

MYCETOZOA FOUND DURING THE HASLEMERE FORAY

By G. LISTER

September 20th. A misty day. Search was made on and about Hurt Hill, Surrey, in woods consisting of oak, some holly and Scotch fir. Large lemon-yellow plasmodia found spreading over dead leaves, matured into *Physarum virescens*, a species not common in Britain but recorded several times before from the Haslemere district. On decaying oak wood, green with gelatinous algae, brought indoors and kept moist, have since appeared over twenty sporangia of *Colloderma oculatum*; this inconspicuous species, only recognised in this country since 1910, appears to be far from uncommon when once its haunts are known.

September 21st was fine with an easterly haze. Henley Common, Sussex, was visited, where the mixed woods consisted of beech, oak and holly: a number of colonies of *Physarum conglomeratum* were found on dead oak leaves; this species had not been found before in Sussex.

September 22nd. This wet day was spent in Charlton Forest on the

South Downs, above Cocking, where the timber consisted chiefly of old beech and ash. A large growth of *Hemitrichia Vesparium* was found on ash; *Diderma floriforme* Pers., developing from the white immature stage, was a new Sussex record; *Cribraria microcarpa* Pers., with minute sporangia on slender stalks varying from 1 to 3 mm. in length, found on decaying beech wood, is new to Britain: it is widely distributed throughout Europe, North America and Asia.

September 23rd was showery. The mixed woods of Grayswood, Surrey, were explored, and also oak woods at Timberscombe, Fernhurst, Sussex. In the latter locality a large growth of *Badhamia rubiginosa* Rost. var. *globosa* was found on a pile of sticks; this variety has usually been obtained on mossy rocks near streams; it is new to Sussex, but has been recorded from Berkshire, Devon, Somerset, Shropshire, Yorkshire, Westmorland, Cumberland and Northumberland; from North Wales and Scotland, and the west of Ireland; from Holstein, Roumania, New Zealand and Hawai.

The total number of species found during the foray is forty-three, which is one more than that obtained during our last autumn foray at Haslemere in 1913.

In the following list *H.* stands for Hurt Hill and Hindhead; *HC.* for Henley Common; *C.* for Charlton Forest; *G.* for Grayswood; *T.* for Timberscombe.

Ceratiomyxa fruticulosa (Mueller) Macbr., *H.*, *C.*
Badhamia capsulifera (Bull.) Berk., *G.*, developed indoors from plasmodium, after being fed on *Stereum hirsutum* for a fortnight.
B. rubiginosa (Chev.) Rost. var. globosa Lister, *T.*
Physarum nutans Pers., *H.*, *HC.*, *C.*, *G.*, *T.*, on dead wood.
P. viride (Bull.) Pers., *H.*, *HC.*, on dead sticks.
P. pusillum (Berk. & Curt.) Lister, *H.*, on dead holly leaves.
P. conglomeratum Rost., *HC.*, on dead oak leaves.
P. virescens Ditm., *H.*, on dead leaves.
Fuligo septica (L.) Gmel., *H.*, *C.*, on stumps.
Craterium minutum (Leers) Fries, *HC.*, on dead leaves.
C. aureum (Schum.) Rost., *HC.*, on dead oak leaves and glass.
Leocarpus fragilis (Dicks.) Rost., *H.*, *HC.*, on sticks.
Diderma effusum (Schwein.) Morgan, *HC.*, on dead leaves.
D. floriforme Pers., *C.*, on dead wood.
Didymium difforme (Pers.) Duby, *HC.*, on dead leaves.
D. squamulosum (Alb. & Schw.) Fries, *H.*, *HC.*, *C.*, on dead leaves.
D. Clavus (Alb. & Schw.) Rob., *HC.*, on dead wood and moss.
D. melanospermum (Pers.) Macbr., *HC.*, on moss.
D. nigripes (Link) Fries, *H.*, *HC.*, on dead leaves.
Colloderma oculatum (Lippert) G. Lister, *H.*, on dead wood.
Stemonitis fusca Roth, *H.*, *HC.*, *C.*, on dead wood.
S. ferruginea (Bull.) Ehrenb., *HC.*, *C.*, *G.*, on dead wood.
S. flavogenita John., *G.*, on dead wood.
S. hyperopta Meylan, *H.*, *G.*, on dead wood.
Comatricha nigra (Pers.) Schroet., *H.*, *HC.*, *G.*, on fallen wood.
C. elegans (Rost.) Lister, *H.*, on decorticate wood.
C. laxa Rost., *H.*, *HC.*, *G.*, on dead wood.
Cribraria argillacea Pers., *H.*, *HC.*, on stumps.

Cribraria rufa (Roth) Rost., *H.*, on dead oak wood.
C. vulgaris Schrad., *H.*, *C.*, on dead wood.
C. microcarpa (Schrad.) Pers., *C.*, on beech wood.
Dictydium cancellatum (Batsch) Macbr., *H.*, *G.*, on dead wood.
Tubifera ferruginosa (Batsch) Gmel., *H.*, on coniferous wood.
Lycogala epidendrum (L.) Fries, *H.*, *HC.*, *C.*, *G.*, on stumps.
Trichia affinis de Bary, *C.*, *G.*, on dead wood.
T. persimilis Karsten, *HC.*, *C.*, on dead wood.
T. decipiens (Pers.) Macbr., *H.*, *C.*, *G.*, on dead wood.
Hemitrichia Vesparium (Batsch) Macbr., *C.*, on fallen wood.
Arcyria cinerea (Bull.) Pers., *C.*, *G.*, on dead wood.
A. pomiformis (Leers) Rost., *H.*, *HC.*, *C.*, *G.*, on oak bough.
A. denudata (L.) Wettst., *H.*, *HC.*, *C.*, *G.*, on dead wood.
A. incarnata Pers., *H.*, *HC.*, *C.*, *G.*, on decayed wood.
A. nutans (Bull.) Grev., *HC.*, on dead wood.

LICHENS OF THE HASLEMERE FORAY

By H. H. KNIGHT

For this very full list of the lichens of the foray at Haslemere I am indebted to Dr W. Watson. Some rare lichens were found by him, *Buellia praecavenda* from the woods at Henley Common, and *Thelidium sparsulum* with very minute perithecia on chalk on the South Downs. On the excursion to Cocking Down he also found a new species of *Thrombium*.

In the following list the localities are denoted by:

1. First day, Hindhead to Haslemere.
2. Second day, Henley Common and woods.
3. Third day, Charlton and Singleton Forests.
4. Fourth day, Grayswood and woods.

H. Haslemere.

2 and 3 are in Sussex, the others in Surrey.

Calicium hyperellum Ach., 2.
Cyphelium inquinans Trev., 4.
Placynthium nigrum S. F. Gray, *H.*
Collema cheileum Ach., 1.
Leptogium turgidum Cromb., *H.*
Peltigera canina Willd., 1, 2.
P. polydactyla Hoffm., 1, 3.
Parmelia physodes Ach., 1, 2, 3.
f. labrosa Ach., 1, 2.
var. platyphylla Ach., 1.
P. perlata Ach., 1, 4.
P. caperata Ach., 1, 2, 3.
P. subaurifera Nyl., 1, 2, 3.
P. saxatilis Ach., 1, 2, 3.
f. furfuracea Schaer., 1, 2, 3.
P. sulcata Tayl., 1.
P. dubia Tayl., 2.
P. revoluta Floerke, 1, 2, 3.
f. minor Harm., 1, 2, 3.
P. fuliginosa Nyl., 1, 2.
var. laetevirens Nyl., 1, 2, 3.
Evernia prunastri Ach., 1, 2, 3.
Usnea florida Web., 1.
var. hirta Ach., 1, 2.
U. plicata Web., 1, 2.
Xanthoria parietina Th. Fr., 1, 2, 3.
Placodium callopismum Mér., 1.
P. murorum DC., 1.
P. citrinum Anzi, 1.
P. ferrugineum var. festivum A. L. Sm., *H.*
Candellariella vitellina Muell.-Arg., *H.*, 3.

Physcia hispida Tuckerm., 1.
var. tenella Nyl., 1.
Lecanora subfusca Ach., 1, 2, 3.
var. chlarona Ach., 2.
var. allophana Ach., 2.
L. rugosa Nyl., 2.
L. glabrata (Ach.) Malme, 2.
L. intumescens Koerb., 2.
L. campestris B. de Lesd., 1, 2.
L. coilocarpa Nyl., 1.
L. atra Ach., 1.
L. pallida Schaer., 1, 2, 4.
L. galactina Ach., 1, 2.
L. varia Ach., 1, 2, 3.
var. conizaeoides A. L. Sm., 2.
L. symmicta Ach., 3.
L. expallens Ach., 2, 3.
var. lutescens Nyl., 3.
L. parella Ach., 1, 2.
L. calcarea Summerf., 1, 2.
var. contorta Hepp., *H.*
Pertusaria globulifera Nyl., 2.
P. faginea Leight., 1, 2, 3.
P. multipuncta Nyl., 2.
P. pertusa Dal. Tor. & Sarnth., 1, 2, 3.
P. leioplaca Schaer., 2, 3.
P. Wulfenii DC., 1, 2, 3.
P. scutellata Harm., 3.
Phlyctis agelaea Koerb., 1, 2, 3.
P. argena Koerb., 2, 3.
Crocynia tephra Hue, *H.*
Baeomyces rufus DC., 1, 3.
B. roseus Pers., 1.
Cladonia sylvatica Hoffm., 1.
C. pyxidata Hoffm., 1, 2, 3.
var. pocillum Fr., 1, 2.
C. fimbriata Fr., 1, 2, 3.
var. subcornuta Nyl., 1, 2, 3.
C. ochrochlora Floerke, 3.
C. pityrea Fr., 1.
C. furcata Schrad., 1, 3.
var. spinosa Leight., 1, 3.
C. rangiformis Hoffm., 1, 3.
C. squamosa Hoffm., 1.
C. coccifera Willd., 1.
C. flabelliformis Wain., 1.
C. macilenta Hoffm., 1.
Lecidea ostreata Schaer., 4.
L. lucida Ach., *H.*
L. quernea Ach., 4.
L. coarctata Nyl., 1.
L. granulosa Schaer., 1.
L. uliginosa Nyl., 1.
L. fuliginea Ach., 1, 2.
L. parasema Ach., 2, 3.
var. flavens Nyl., 2, 3.
var. elaeochroma Ach., 2, 3.
L. contigua Fr., 1.
f. calcarea Leight., 2.
L. sorediza Nyl., 1.
Biatorina Griffithii Massal., 2.
B. lenticularis Koerb., *H.*
Bilimbia sabuletorum Br. & Rostr., 1.
Buellia canescens De Not., 1.
B. praecavenda A. L. Sm., 2.
Rhizocarpon alboatrum var. epipolium A. L. Sm., 3.
R. viridiatrum Koerb., 3.
R. petraeum Massal., 2.
R. confervoides DC., 3.
Arthonia lurida Ach., 2.
var. spadicea Nyl., 2.
A. radiata Ach., 2.
var. Swartziana Sydow, 2, 3.
Graphis elegans Ach., 1, 2, 3.
f. stellata Leight., 1, 2.
G. scripta Ach., 1, 2, 3.
f. recta Nyl., 2.
Phaeographis inusta Muell.-Arg., 2.
P. dendritica Muell.-Arg., 2.
Graphina anguina Muell.-Arg., 2.
Enterographa crassa Fée, 2, 3.
Verrucaria viridula Ach., 2, 3.
V. nigrescens Pers., 1, 2, 3.
V. maculiformis Krempelh., 3.
V. muralis Ach., 1, 3.
var. submuralis f. minor B. de Lesd., 3.
Thelidium sparsulum A. L. Sm., 3.
Arthopyrenia fallax Arn., 1.
Porina carpinea Zahlbr., 1, 2.
Pyrenula nitida Ach., 2, 3.

PRESIDENTIAL ADDRESS

By G. LISTER, F.L.S.

FIELD NOTES ON MYCETOZOA

When you did me the honour of electing me to be your president last year, I decided at once that the subject of my presidential address should be some aspect of the Mycetozoa, the only group with which I am fairly familiar, but I was doubtful as to what aspect should be selected which might prove of interest.

Since the third edition of *The British Museum Catalogue of Mycetozoa* appeared in 1924, numerous papers dealing with the subject from either a systematic, cytological or chemical point of view have been published. We are indebted to Dr Y. Emoto for drawing up a list of the papers that were written between 1925 and 1931*. They amount to nearly a hundred and fifty, and if those published in the present year were added, that number would be surpassed. Ninety-nine of the papers refer to the systematic side of the subject. Naturally they vary much in importance, some articles being local lists of species, while others represent careful and elaborate studies of life histories. It is interesting to note that the United States takes the lead in the abundance of its contributions; England comes next, followed by Japan; most European nationalities are represented, Germany supplying most material, Poland, Roumania, Switzerland, France and Russia—and so on, giving successively fewer contributions. Such a series is, of course, no guide to the value of the publications, but it may give a slight clue to the interest shown in the subject in the different countries.

I confess I have not read nearly all these hundred and fifty papers; some are written in a language unknown to me; as a rule, however, the authors, whether Russian, Serbian or Japanese, give a *résumé* in either French, German or English. In any case we see that Mycetozoa are far from being neglected.

It is about the out-of-door study of Mycetozoa that I am asking you to listen to me now, associated especially with the results obtained by some pioneers in field work to whom I am indebted both for their correspondence and for the specimens they have sent.

In Roumania the study of Mycetozoa in the field has been pursued by Prof. Marçel Brandza with remarkable success. When he began to

* "A list of the literature on the Myxomycetes (1) (1925–1928)," by Y. Emoto, *Bot. Gaz.* (*Tokyo*), XLIII, 1–5 (1929), and a second list (2) (1928–1931), *ibid.* XLV, 570–5 (1931).

investigate the subject about thirty years ago, only twenty-eight species had been recorded for his country. In his first paper on the subject, entitled "Myxomycètes de Roumanie*," published in 1914, he enumerates 110 species, most of which had been found by himself. In a certain number of cases where he was not sure of the identification he had the rare discretion to describe and illustrate these gatherings, referring to them as "*species non-determinatae*"; they were numbered and included in a series of exsiccatae which were distributed freely to various museums, including the British Museum, and in this way his doubtful species could be identified by specialists.

A series of articles dealing with Mycetozoa has since been published by him. One of them, "Sur l'apparition des Myxomycètes dans la ville de Bucharest sur les substratums préparés d'avance†," describes an experiment he made in preparing what may be called "nurseries" in the city of Bucharest, where he hoped chance spores of Mycetozoa might find a home and develop. They were prepared in autumn in various parks and gardens—some bordering on the dusty street, others in more retired places, and were composed of varied materials; one was of dead pine branches, one of old poplar boughs, one of sawdust, while another was a mixture of branches, leaves, manure and paper rubbish: some were in the shade, others exposed to sunlight. By the following May and June every one of the nurseries had produced a harvest of Mycetozoa, and he gives an analysis of the results. Thirty-three species in all appeared, including several that are usually considered rare, and nine which had not been recorded before from Roumania. The nurseries situated in the dusty centre of the city yielded nearly double the number of those in the more secluded heaps—a result which suggests to Prof. Brandza that the dust of a great town, with impurities of all sorts, may really be favourable to the growth of Mycetozoa. There is no doubt that the deep snow with which all the heaps were thickly covered during long months of winter afforded suitable and undisturbed conditions for the development of plasmodia.

Prof. Brandza has extended our knowledge of the habitats of Mycetozoa in several directions. In a letter written in the autumn of 1925, he describes a great storm which swept over the mountain woods of Moldavia in the preceding August. In the department of Néamtz alone, where he was staying at the time, over half a million trees, chiefly conifers and old oaks, were blown down. On the day after the storm he went out to examine these fallen trees, and found what he describes as "a brilliant vegetation of Myxomycetes" on the moss and lichens clothing the upper branches. The species forming this "brilliant vegetation" did not prove to be peculiar to the lofty

* In *Ann. Sci. de l'Université de Jassy*, VIII, 259–94.
† *Ibid.* XIII, 93–9 (1924).

situation; one of them, however, *Amaurochaete comata* G. Lister & Brandza, happened to be new to science. Such an experience opens up vistas of the unsuspected life that may be flourishing overhead in our woodlands.

In a paper entitled "Sur la Polychromie des Myxomycètes vivant en plein Soleil*," Prof. Brandza describes another habitat rich in Mycetozoa. It is afforded by the old plank roofs of huts built in the forest clearings: the planks are of fir wood and in time become thickly overgrown with moss and lichen. Of the numerous species of Mycetozoa found here (and represented also in the woods round about) over fifty belonged to the suborder Calcarineae, and he has observed that the unusual conditions to which they had been subjected, such as exposure to strong light and to rapid evaporation, often caused curious modifications in both the colour and texture of the sporangium wall and tended also to reduce the amount of calcareous matter in the lime-knots of the capillitium. The spores alone seemed to be unaffected by the changed conditions. In the genus *Physarum* the colour of the sporangia was apt to become more brilliant than in the corresponding sporangia in the shady woods around: thus *P. bogorcense* Racib. became bright yellow instead of pale buff; *P. Serpula* Morgan and *P. tenerum* Rex were orange instead of yellow. Certain abnormalities were also noted. In three species of *Craterium*, the exposed sporangia tended to be spherical rather than goblet-shaped, and to dehisce irregularly instead of by a lid. In *Cienkowskia reticulata* Rost. the usual thin calcareous plates of the capillitium were replaced by irregular *Physarum*-like lime-knots. *Diderma rugosum* Lister was apt to lose the characteristic club-shaped columella—and so on. If, however, he transferred the plasmodium of these species from the roofs and allowed it to mature slowly in the shady moisture of the woods, normal sporangia were developed. *Physarum nutans* Pers. was extremely abundant on these mossy roofs. He writes that the plasmodium is either colourless or pale yellow. With it he made the following experiments. Having divided a mass of the colourless plasmodium into two parts, one part was kept shaded and moist, and the other part, after the substratum had been soaked in water, was exposed to sunlight: the shaded plasmodium produced normal grey sporangia; the exposed plasmodium matured into brown sporangia with brown lime-knots. Similar experiments were made with what he describes as the pale yellow plasmodium of this species; the part kept moist and shaded had greenish grey sporangia, while the part exposed to rapid evaporation produced bright yellow sporangia. Prof. Brandza is inclined to conclude from these observations that the closely allied yellow species *Physarum viride* Pers. is merely a form of *P. nutans* induced by exposure to strong light and air. His experiments are sug-

* *Compt. Rend. de l'Acad. Sciences*, CLXXXII, 987 (1926).

gestive, and those who observe Mycetozoa in the field would do well to note how far they can confirm his results. He has kindly sent me specimens of white and yellow sporangia matured, under varied conditions of light, from the pale yellow plasmodium; I find those greyish white sporangia which I have examined with transmitted light show a yellow tint in the lime granules of both the walls and lime-knots, which suggests that we are dealing with the pale form, the var. *incanum*, of *P. viride*, and not with *P. nutans*. My own experience in the field has tended to show that the distinction between *Physarum nutans* and *P. viride* is of a more fundamental nature; typical grey sporangia of *Physarum nutans* may be found on dead wood either in the light or in shade, and the yellow sporangia of *Physarum viride* do not occur always in exposed situations*.

Similar experiments carried out with *P. globuliferum* Pers. showed that sporangia developed in shade were white, and those exposed to rapid evaporation in strong light had a brown tint, and resembled *P. murinum* Lister so closely that he suggests that the latter is a variety of *P. globuliferum* induced by strong illumination at the time of maturing.

In a paper entitled "Sur la fusion ou séparation des plasmodiums prise comme criteriums dans la définition de l'espèce chez les Myxomycètes†," Prof. Brandza describes experiments made with several species in which the plasmodium is sometimes one colour, sometimes another. It should perhaps be mentioned that this colour difference is not associated with the colour of the food which has been ingested, for, at the stage when sporangia are about to form, all undigested food and refuse matter has been extruded. Typical *Fuligo septica* Gmel., the "Flowers of Tan," develops from either yellow or cream-coloured plasmodium. By placing two masses of yellow plasmodium in close contact when they were about to fructify he found that they readily fused and formed a single aethalium; the same result was obtained by placing two of the cream-coloured plasmodia together; they fused and produced one aethalium. But he could never induce the yellow plasmodium to fuse with the cream-coloured one; the former produced either an ecorticate yellow aethalium or an aethalium with a yellowish brown cortex; from the cream-coloured plasmodium either a yellow or a white aethalium matured. He suggests that the two colours of the plasmodium mark the existence of two physiological species.

Tubifera ferruginosa Gmel. has, he notes, plasmodium which may be either colourless or bright yellow when it emerges from the wood

* Prof. Brandza observes that the variety *aurantium* of *P. viride* arises from orange plasmodium, and the sporangia maturing from it are always orange under whatever conditions they develop; he thinks that it represents a distinct species, and he is probably right.

† *Compt. Rend.* CLXXXV, 1072 (1927).

where it has been feeding: here also he found that yellow would fuse with yellow plasmodium, and colourless with colourless, but never yellow with colourless. Some slight differences between sporangia maturing from the yellow or colourless plasmodia respectively could be detected, but these were not sufficient to suggest a specific distinction.

Experiments made with the yellow and colourless plasmodia of the common leaf-haunting species *Didymium squamulosum* Fries also proved that no fusion could be induced between plasmodia of different colours, although the sporangia developed from each were quite indistinguishable.

These observations showing the attraction or repulsion between plasmodia of the same species are interesting, and reveal unexpected and subtle distinctions.

In dealing with *Fuligo septica* he refers to experiments in which he divided a mass of plasmodium into two parts, and by subjecting them to different conditions (conditions which he does not describe) he obtained at length either a corticate or ecorticate aethalium.

It may be mentioned that the cortex in *Fuligo*, as in most other aethalia, consists of one or more outer layers of sporangia from which all the spore-plasm has retreated; it is composed therefore of empty membranous tubes, which form a protecting covering within which the inner sporangia can mature perfectly; the drier the weather the thicker will be the layers of barren sporangia forming the cortex. If, however, the emerging plasmodium is kept moist under a glass shade, and is protected from currents of air, no cortex is formed, and all the sporangia are spore-bearing. Under these conditions, the aethalium usually forms a less compact mass, and may even produce some free sporangia scattered beyond its borders. Some writers have regarded the aethalium as a simpler and more primitive structure than groups of separate sporangia, but on what grounds it is difficult to understand.

In his "Observations sur quelques sclèrotes de Myxomycètes calcaires*" Prof. Brandza describes the structure of sclerotia of a large number of species, many of them usually considered rare, but which he finds abundant in the Moldavian woods. He notes that when the sclerotia of these "calcareous" species are formed in still air they are without any calcareous crust; when formed in a current of air, whether moist or dry, a protecting crust is developed. He gives interesting details of the microscopic appearance of various types of sclerotium cysts, although some of these details are not altogether easy to follow.

Prof. Brandza's most important systematic paper, "Les Myxomycètes de Néamtz†," gives the result of twelve years' study of a small area in the Moldavian mountains. It lies around the monastery of

* In *Le Botaniste*, Sér. XX, 117–46, figs. 1–16 (1928).

† In *Bull. Soc. Mycol. France*, XLIV, 249–300, Pls. XIV–XVII (1929).

Néamtz, at an altitude of 700 metres; the climate is moist, and the mountain slopes are covered with great forests consisting of conifers —pine, spruce and fir—also with beech and oak, some aspen and hornbeam. Fallen timber is allowed to decay here undisturbed, thus affording ideal conditions for the development of many Mycetozoa. From this area, which has a radius of about three kilometres, he has recorded 181 species, nine of which had not been found previously in Europe. Considering that the total number of known species is about 300, the richness which this little district is found to possess when intensively studied is astonishing. Of the nine species new to Europe, all have been recorded from North America, and most of them also from Ceylon, Japan and Eastern Asia, thus confirming the evidence for the very wide distribution of most species of Mycetozoa. His enumeration is no bare list of names, but is enriched by original observations as to the habitats, periodicity, abundance or rarity of each species, and the variation they show under different conditions of development. Two examples may be quoted. *Diderma ochraceum* G. F. Hoffmann is described as abundant only from September till the time of snow, appearing on moss-covered logs lying in boggy places. If the sporangia mature in moist air they develop normally, that is they are ochraceous in colour and have a double peridium in which are embedded numerous round calcareous granules; when maturing quickly in dry air, the peridium is single, brown, and the calcareous layer, instead of consisting of round granules, is represented by flat crystalline scales, like those of a *Lepidoderma*. Indeed he finds that it can then only be distinguished from *Lepidoderma tigrinum*, with which it is often found associated, by the complete absence of a stalk. He does not refer to the difference in the colour of the plasmodium of these two species, which appears to be a constant mark of distinction; that of *Diderma ochraceum* being sulphur-yellow and that of *Lepidoderma tigrinum* being orange; possibly this character is not of great importance.

In writing of *Cribraria purpurea* Schrader, usually considered a rare species, he observes that it does not appear in the Néamtz woods until October, and then covers decayed coniferous logs in vast colonies. The sporangia are at first brilliant reddish purple; later, after rain, they become "violet cardinal" in colour; the red pigment easily dissolves in water, and this explains the violet stain imparted to the wood from which the sporangia arise. These extracts may perhaps show something of the lively out-of-door character of the paper, which is illustrated by four excellent coloured plates made from his own drawings.

In concluding these notes on Prof. Brandza's work reference should be made to the fine sets of specimens illustrating the Mycetozoa of Roumania which he has distributed, one of which is destined for the British Museum collection.

A fellow-countryman of Prof. Brandza's, Dr M. Solacolu, has recently published a paper* on the colouring matter in sporangia of Mycetozoa. He works with material supplied him by Prof. Brandza. The species dealt with are arranged in three groups according to whether the sporangia are red, yellow or brown. He finds that the red pigments only are soluble in water. On the whole, after treating the pigments with various reagents, he states that they respond in much the same way as do the pigments of fungi and lichens.

Another worker on Mycetozoa to whom all students of the subject are indebted is M. Charles Meylan. Living as he does at Ste Croix in the Swiss Jura, at an altitude of 3500 feet, with mountain ranges extending both to the north and south, and the wide plain with the Lake of Neuchatel lying to the east, he has unusual opportunities for studying both the lowland and alpine vegetation of his district. In the intervals of his work in the teaching profession, he has investigated the cryptogamic flora generally, and has concentrated especially perhaps on the Mycetozoa. Each year for the last thirty years he has noted them from the time when the snow melts in April or May till it again covers the land in the autumn. During the winter he examines his gatherings critically and has written summaries of his observations and discoveries. The result is a series of papers of much interest dealing with the species according to the altitude at which they appear, their varieties and habitats. He has created new genera, a number of new species, and has shed light on many difficult forms. He has dealt fully with what he terms "les espèces nivales," the species that appear in the spring and are associated with the melting of the winter snows. His notes on these "snow species" are of unique value, as this field of research has never been studied thoroughly before.

M. Meylan finds that if the autumn snow falls late and melts early in the following spring the harvest of Mycetozoa may be scanty or even nothing, and this may happen for several years in succession. If heavy snow falls in October and lasts till the following April or May, and then melts with a rush of warm weather, the abundance of Mycetozoa which then appears is almost beyond belief. He describes how, after a layer of snow a foot or more thick has lain over the mountain sides for five or six months, and then melts with the warmth of spring, the soil of the pastures and forest clearings becomes covered with a crust, white or of various colours, from the thousands or rather millions of sporangia which develop as the snow-line retreats. They clothe the débris left by the snow, the stalks of dead grass, the gentian and raspberry stems, or the nettles and thistles growing near the upland châlets. When the old snow-edge is carefully removed, sporangia are found moist and freshly forming beneath it, ready to dry, dehisce

* "Sur les matières colorantes de quelques Myxomycètes" in *Le Botaniste*, Sér. XXIV, 107–38, Pls. XIII, XIV (1932).

and disperse their spores as soon as they are exposed to the open air. If the edge of the retreating snow is broken away still further, plasmodium may be found creeping over and feeding on the sodden turf and dead twigs in what has been for months an even temperature of 32° F. Should the weather keep fine, this amazing "carpet" of sporangia will remain intact for some days, but it disappears at once under heavy rain, leaving hardly a trace behind. He writes that it is difficult to make any estimate of the hosts of sporangia formed in a favourable spring. Some species, such as *Diderma niveum*, may be found covering square metres with their minute white spheres. He notes that species with white sporangia appear to choose the most exposed situations in which to fructify, while yellow sporangia such as those of *Physarum alpinum* G. Lister and the iridescent or blackish sporangia of the genus *Lamproderma* are usually found on the undersides of leaves or in shady crevices, as if direct sunshine was too strong for their favourable development. In all cases, sunny slopes of the mountains are found to afford a richer harvest than northern or shaded aspects; M. Meylan suggests that this may be due to the penetration of snow by sunshine being a necessary factor in enabling the spores to germinate. He notes that three-quarters of the species associated with snow belong to two genera only, namely to *Diderma* and *Lamproderma*.

As might be expected from the exposed situations in which they occur, the sporangia are often subjected to conditions unfavourable to normal development, with the result that abnormalities appear and characters we rely on even for generic distinction may be entirely absent. Some species of *Lamproderma* appear to be extremely susceptible to changes in external conditions. One of the normal characteristics of the genus is the iridescent membranous sporangium wall, yet M. Meylan has found near Ste Croix a growth of *L. violaceum* in which the stalked sporangia were more or less completely covered with a white envelope of minute calcareous granules—as if the species had strayed into the suborder Calcarineae!

In one of my alpine gatherings, named by M. Meylan *L. splendens*, one of his new species, the refuse matter from the plasmodium, which is usually completely extruded before the sporangia begin to be formed, appears as a thick brown layer covering the sporangium wall; in other respects the growth is normal. Even in lowland species of *Lamproderma* strange freaks may be met with. A Scotch gathering of *L. echinulatum* Rost. has part of the sporangium wall in one specimen densely studded with black spinules like those which adorn its spores. Perhaps one of the most bewildering varieties occurs in the lowland form of *Lamproderma atrosporum* Meylan, where a fairly normal stalked form, with black columella and dark reticulated spores, has been found repeatedly and closely associated with a weak sessile form without columella and with pale warted spores; yet there appears to be no

doubt that both forms belong to this species. From these remarks it might be inferred that the characters of many species of Mycetozoa are in a chaotic state of confusion, but indeed this is not the case; for it is the usual constancy of form, down to minute details of spore-marking, which is most impressive and which makes these exceptions the more remarkable. In his recent paper "Les espèces nivales du genre *Lamproderma**" M. Meylan deals with the alpine forms of this difficult genus as he meets with them in Switzerland. He divides the cumbrous species *L. violaceum* Rost., with its two alpine varieties, var. *Sauteri* and var. *Carestiae* (as given in the British Museum Catalogue), into a number of distinct species. Typical *L. violaceum* occurs only in the lowlands; each of the two alpine varieties he divides, roughly speaking, into three species: altogether he recognises ten species characteristic of these high altitudes, eight of which (with numerous varieties) he has been the first to describe clearly. He frankly admits that forms not true to type appear frequently in unfavourable seasons, and occasionally sporangia of one species may closely simulate those of another, and then it is only by intimate and wide experience that one can hope to sort them into their right places. How far his system will prove entirely reliable, time and research will show. Whether a form is to be regarded as a species or a variety may be, we know, a matter of personal opinion. M. Meylan is one who thinks that the student is more helped by dealing with a number of closely related species than by dealing with fewer species embracing well-marked varieties, and there is much to be said in favour of his view. He has produced, as the result of his unequalled acquaintance with alpine forms, what he finds to be a good working classification, and his conclusions deserve both our respect and gratitude.

Those of us who rarely visit the Swiss Alps until full summer have not had the opportunity of witnessing the dramatic rush of spring Mycetozoa which he graphically describes, but even summer explorations in the zone of melting snow in alpine meadows have brought much reward.

That great success is by no means always to be found we learn from the account given by M. J. Jarocki of his experiences during two successive summer vacations in mountain regions. In a paper entitled "Mycetozoa from the Polish Eastern Carpathians†" he writes: "No alpine forms of the type of 'espèces nivales' of Ch. Meylan have been encountered in Czarnohora, in spite of careful search among dead herbage, on the borders of forests and in alpine pastures. Even in the vicinity of thawing patches of snow lying in the neighbourhood of vegetable débris the author was unable to discover any Mycetozoa. It is possible that these should have been searched for in the early

* *Bull. Soc. Vaudoise des Sciences Naturelles*, LVII, 359–73 (Séance, Dec. 1931).
† In *Bull. de l'Acad. Polonaise des Sciences, etc.*, Série B, pp. 447–64 (1931).

spring, or that certain factors come into play here, rendering conditions very different to those of the Swiss Alps or Jura Mountains." He compares the sparseness of his collections in the forest region with the wealth of material found by Prof. Brandza in the neighbouring Moldavian Carpathians. He attributes this in part to the lower woods in his district being composed only of spruce and beech, while the subalpine zone is clothed with a "scrub" of Mountain Pine (*Pinus mughus*) and Alpine Alder (*Alnus viridis*), neither of which furnish conditions favourable for the development of Mycetozoa. He draws attention to the strikingly small number of the suborder Calcarineae found in these woods, and suggests this may be due to the low calcium content of the soil. He observes, however, that two seasons' search is not a long enough period from which to base definite conclusions. Yet compared with many other forest regions his list of sixty-seven species is by no means poor. Fourteen of them had not before been recorded from Polish territory. Among them is *Barbeyella minutissima* of Meylan, a species known previously only from the Jura Mountains, whose minute stalked black sporangia are barely discernible without the aid of a lens. In the Polish Tatra Mountains Dr Jarocki has rediscovered the even smaller *Kleistobolus pusillus* Lippert, a species which had been lost sight of since its discovery by Lippert in 1894, when it appeared in a culture of wood brought from Upper Austria. I mention Dr Jarocki's work here on account of his search for alpine species; he is one of a number of the compatriots of Rostafinski who have carried on the tradition of that master's classic work. The names of Cienkowski, Raciborski, Skupienski and others are familiar to students of Mycetozoa for their valuable researches.

Turning to the United States, Mr Robert Hagelstein describes a habitat for Mycetozoa that might well have escaped notice. Fringing the south coast of Long Island, in the State of New York, are a series of ocean beaches more or less separated from the main island. Jones Beach, where he has a summer cottage, is almost completely surrounded by water and is thirteen miles long and varies from a few hundred feet to nearly a mile wide. He describes it as a narrow sandy waste, with low beach vegetation and no trees; yet in this unpromising situation he has obtained fifty-eight species, forty-three of which appeared on decaying grasses close to the sand, on partly buried driftwood, paper, clothing and other rubbish strewn about the beach; the remaining species appeared in similar habitats, also on logs, boards, dead herbaceous stems and bayberry leaves (*Myrica cerifera* L.). Seven of these species had not been recorded from the main island. There the extremely rich hunting-grounds provided by the moist woods have been picturesquely described by Mr William Crowther in the *National Geographical Magazine* for April, 1926; his coloured illustrations of highly magnified sporangia are exceptionally

lifelike and striking. From the descriptions and collections made by my friend Dr W. C. Sturgis, some parts of the States of Colorado and Massachusetts appear to be equally rich in Mycetozoa.

Mr F. A. Gilbert, writing on "Myxomycetes from Eastern Massachusetts*," states that of the eighty-nine species and varieties that he has found there about eighteen occur in profusion, and thirty-five are common; he concludes "that the district is not outstanding with regard to its myxomycetous flora, but that it does yield rather varied and interesting collections if worked intensively." I may mention that Mr Gilbert has written a series of valuable papers on the germination and feeding of swarmspores.

From North India my friendly correspondent the late Mrs John Drake has sent me many packages of Mycetozoa collected by herself and her daughter in both the hills and the plains. Amongst the species found at Serampur, near Calcutta, was a minute and undescribed *Didymium*, on dead leaves; it has since been sent me by Mr Hagelstein from Long Island, New York, and from Japan, where it was gathered by the Emperor in the palace grounds near Tokyo. It has now received the name of *D. ochroideum* G. Lister. Writing from Serampur College in 1924, Mrs Drake described how in the previous December they had put some withered leaves, twigs and small branches into two old enamelled wash-basins, with holes in them, and placed them on the verandah, screened from the sun, and watered them frequently. She wrote: "In January we had our first gathering of Mycetozoa there, *Diachea leucopoda* in profusion, followed by *Arcyrea cinerea*, *Physarum Maydis*, *Hemitrichia Serpula*, *Fuligo*, a *Perichaena* and a *Lamproderma*. We could always be sure of finding *Diachea*."

Such an experience could never be obtained, I think, in England, where the dead plants would soon, one would expect, be a prey to mould and other fungi.

It was in 1884 that the late H. Marshall Ward, in a paper entitled "The Morphology and Physiology of an aquatic Myxomycete†," described how the whole life history of *Didymium difforme* might be completed on the roots of a hyacinth bulb grown in water in a glass vase.

Lately Mr Ashley G. Lowndes, in connection with his studies on Entomostraca, finds that he can obtain plasmodia on which to feed these minute crustaceans by simply submerging a quantity of dead elm leaves in a jar of water; after ten days or so, plasmodia begin to appear under water on the glass walls of the jar, and soon increase in numbers sufficient for his purpose. The species producing the plasmodia is also *Didymium difforme* Duby.

Several instances have been recorded of sporangia of this species occurring on bulbs beneath the soil. Miss Cayley has found them on

* In *Rhodora*, XXIX, 165–73 (1927).

† *Quart. Journ. Microsc. Science*, N.S. XXIV, 64–8, 2 Plates.

a tulip bulb growing eight inches below the surface. Such records are valuable in adding to the rather scanty evidence we possess of Mycetozoa living underground; it is possible this habitat may prove to be more frequently adopted than is yet realised.

From the above rather desultory notes it will be seen how new haunts of these attractive creatures, animals or plants, whichever we choose to call them, are being discovered.

The subject is one in which fresh problems, whether of their behaviour or their variation, are constantly presenting themselves, while the elusive uncertainty of their appearance in the field adds a charm to their pursuit.

THE SYSTEMIC INFECTION OF GRASSES BY *EPICHLOE TYPHINA* (PERS.) TUL.

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(With Plates I–III)

I. Historical

Epichloe typhina (Pers.) Tul. was first recorded in 1798 by Persoon under the name *Sphaeria typhina*. It was referred later to the genus *Epichloe* by Tulasne (26), who described and figured the reproductive part of the fungus. Germination of conidia and ascospores was obtained and figured by Brefeld (4), and popular accounts of the disease with special reference to severe outbreaks on *Phleum pratense* were published by Prillieux (21) and Eriksson (5).

As early as 1863, de Bary traced the connection between mycelium in the host plant and the external fruiting organs of the fungus. He described the distribution of the slender, septate and sparsely branched mycelium in the stems immediately below the stroma and in some of the adjacent leafy tillers. He showed that the conidia, and later the perithecia, develop from this mycelium and thus refuted the view put forward by Bail (3) that *Sphaeria typhina* is a pure epiphyte living only on the surface of the leaf-sheath.

The perennial character of the mycelium in this species has been indicated by a single recorded experiment in which an infected plant, broken up into a number of parts, produced only infected straws (12).

Frequent references in literature indicate that *Epichloe typhina* has a wide distribution on grasses in Europe. It appears to be less common in America (25). Oudemans (16) lists the fungus on twenty-six species of Gramineae.

In a recent paper Vladimirskaja (27) records it not only on pasture grasses, but also on wheat and rye in Russia. The fungus, moreover, was grown in pure culture on various media on some of which perithecia-like bodies developed, but they contained no asci. It is concluded as the result of an extensive series of inoculation experiments that invasion of the plant takes place through the young tiller buds, but evidence rested only on the presence of mycelium in the inoculated buds and not on the development of conidia or perithecia on the mature plant. Full reproduction of the disease has not yet been achieved by direct inoculation.

The economic significance of *Epichloe typhina* as a disease of grasses

lies chiefly in the damage done to those species which are grown for commercial seed production or for experimental study. It is doubtful if it often causes appreciable injury to meadows and pastures, although, judging by material brought from old pastures to the Welsh Plant Breeding Station, perennial grasses in long leys must often be attacked. Alleged cases of animals injured or poisoned by the fungus have not been confirmed by any critical tests (11, 15, 21).

II. Introduction

Epichloe typhina has been recorded on nine species* of Gramineae in the Aberystwyth district, and infected plants of three others† have been received from different parts of the country. Field observations have been made at the Station since 1921, and experimental work on the disease has been in progress since 1927 (22).

An important section of the work, namely the rôle of conidia and ascospores in the transmission of the disease, is still under investigation, since an extensive series of inoculation experiments has yielded almost entirely negative results. Arising out of the field observations and experimental work, which has been carried out with cultures of single plants and their propagants, a number of facts have been established which bear upon the problem of disease transmission. One outstanding result which is of distinct importance in connection with inoculation studies is the fact that the absence of reproductive organs at the appropriate time of the year does not necessarily mean that a plant is free from infection. This condition of "invisible or latent infection" is discussed in Section III, together with other facts of biological interest.

Section IV deals with the transmission of the disease by mycelium carried in the seed. The data refer to a strain of the fungus growing on *Festuca rubra*, but evidence is available showing that this method of transmission is in all probability not exclusively confined to this particular host.

III. Transmission by vegetative propagation of the host plant

(*a*) *Distribution of mycelium in the plant.* The mycelium of *Epichloe typhina* is very slender, measuring only 1–2μ in diameter. In the vegetative organs of the host it is somewhat sparsely septate and runs for long distances without branching (Pl. I, figs. 1, 2, 3). It stains readily with cotton blue and with gentian violet followed by Gram's iodine

* *Phleum pratense, Dactylis glomerata, Festuca rubra, Alopecurus pratensis, Poa trivialis, Holcus lanatus, Holcus mollis, Agrostis stolonifera, Brachypodium sylvaticum.*

† *Koeleria cristata, Poa bulbosa, Festuca ovina.*

solution, and these stains have been almost exclusively used in the present work*.

The fungus develops for the greater part of the year as an intercellular parasite living entirely within the host except for a few rare, isolated hyphae which sometimes emerge between epidermal cells. Prior to the formation of the well-known conidial stroma the mycelium becomes abundant in and between the leaf-sheaths, binding these together in a solid mass and preventing the exsertion of the inflorescence. At this stage the mycelium usually becomes intracellular, invading parenchymatous cells and xylem vessels. Cells of the assimilating tissue are often separated from each other by the growth of hyphae along the middle lamella, and the chloroplasts become disorganised. It is only when the fungus fruits that the tissues of the host suffer visible necrosis. In the expanded foliage leaf of an infected plant cells which are actually in contact with the mycelial strands traversing the chlorophyll tissue are apparently healthy.

Mycelium has been found in infected plants at all times of the year. It can be readily demonstrated at any season in longitudinal sections of tiller buds, leaf-blades, leaf-sheaths, root-stocks, creeping stems of such grasses as *Festuca rubra* and *Holcus mollis*, and in the thick scale leaves of the bulbils of *Poa bulbosa*.

During the flowering period mycelium can be found in the pith of infected fertile tillers. A convenient method of demonstrating its presence is to make a "pith scraping" by slitting the stem longitudinally with a sharp knife and removing the pith from both halves, afterwards staining it with cotton blue. In such preparations numerous long strands of blue mycelium stand out clearly from the colourless cells of the pith. The method has proved of special value in *Festuca rubra*, where panicles which show no external trace of infection are found to possess a pith invaded by the mycelium (see p. 41). That such mycelium is correctly identified has been proved by taking out long strips of pith with sterile forceps and placing them upon nutrient media. With suitable care to prevent contamination, pure cultures of *Epichloe typhina* with typical conidia have been obtained.

Roots of infected plants of various species have been examined, but so far mycelium has not been traced beyond the base of a root which is covered by the cortical tissues of the stem. Mycelium of a different type has been found in the roots of some grasses (*Festuca rubra*, *Alopecurus pratensis* and *Dactylis glomerata*). It was invariably coarse (about 6·6μ in diameter), intracellular and non-septate, correspond-

* Aniline gentian violet was prepared according to the formula given with the "Soloid" brand supplied by Messrs Burroughs Wellcome and Co. A fresh solution was prepared each week as the liquid stain does not keep. The technique was similar to that used by Miss McLennan for the *Lolium* fungus(13). Unfortunately there is a tendency for the stained mycelium to fade after several years.

ing with the typical Phycomycete type which appears to be so often associated with the roots of higher plants (23, 24, 14, 17, 18). It is clearly distinct from that of *Epichloe typhina*.

(*b*) *Observations on the seasonal reappearance of the fungus and its capacity for fruiting.* The development of the conidial stroma in the host plant coincides with the period of panicle exsertion in healthy individuals. In this district the first signs of *E. typhina* are usually evident from the beginning to the middle of May. It appears first on the early grasses such as *Alopecurus pratensis*, later on *Dactylis glomerata* and *Festuca rubra*, and last of all on *Phleum pratense*, which is a late-flowering species. Thus in 1928 some records of the first appearance of the conidial stage were as follows: *Alopecurus pratensis*, May 1st; *Dactylis glomerata*, May 8th and *Festuca rubra*, May 24th.

Ripe ascospores, which are capable of immediate germination, are usually discharged about a month after the first appearance of the conidial stage. In *Dactylis* they are available at the end of June and during the greater part of July. On the same plant a few tillers may be found bearing conidia and rarely the conidial stage can be found again as late as October, but this seems to be exceptional. Usually the period of development external to the host is only three months, May to July for the early grasses, June to August for the late ones.

When the ascospores have been shed the perithecial layer dries, sometimes becomes mouldy (*Cladosporium* sp.) and sometimes simply falls off in flakes. It is obviously not correct to state that the perithecia constitute the over-wintering stage of the fungus. For eight or nine months of the year infected plants cannot be distinguished from healthy individuals except by microscopic examination. In perennial grasses the fungus persists from year to year by means of mycelium in vegetative organs of the host, and usually, though not always, it reappears regularly on the same individual.

Observations were made for two consecutive years on a collection of single plants of *Dactylis glomerata*, which was severely attacked by the disease (Knoll, 1927–8). In a population of 863 plants derived from various sources, 363 showed the disease both years, 22 were visibly infected in 1928 but not in 1927, while 25 were recorded as infected in 1927 and showed no infection in 1928. The degree of infection, as indicated by the percentage of fertile tillers carrying perithecia, gave a range of variation from 0·7 (1 in 150) to 100 per cent. Only five plants showed complete suppression of panicles, and these all occurred among the indigenous strains. Further evidence of a "latency" in the disease will be found in the data relating to the propagants of infected plants (p. 34).

Reference should be made to the erratic behaviour of plants in the production of perithecia. Six plants of *Dactylis* which produced an

abundance of mature perithecia in 1929 gave none in 1931 and 1932, the infected tillers becoming dry and withered. This might have been regarded as a seasonal effect had not another plant in the same plot, which showed infection for the first time in 1931, given good perithecia in that and the following year. The premature death of the stromata in the six plants mentioned is believed to be related to the age of these clones and to the fact that they had been grown for some time in the same place. A similar effect has been noted in some plants which were obviously pot-bound. *Cladosporium* sp. and larvae of the fly, *Anthomyia spreta* Meig.*, also attack young stromata and count among factors which hinder their perfect development.

The capacity for producing perithecia is also a function of strain. Many hundreds of infected plants of *Festuca rubra* have been observed in the course of this work and not more than ten have been found bearing ripe perithecia. On these the number varies considerably from season to season, but these selected individuals are more likely to produce perithecia than are other infected plants not selected for this character. Other features peculiar to the disease on *F. rubra* are discussed in Section IV.

(*c*) *Multiplication of infected clones in various grasses.* Proof that the disease is transmitted by vegetative propagation of the host has been obtained repeatedly in the course of this work. It follows naturally from the fact that the vegetative organs are permeated by mycelium. A few specific examples of the type of result obtained are given in Table I. The most striking example of this method of distribution is that of the single plant of *Dactylis glomerata* which was successfully broken up to form 287 propagants, only one of which failed to produce the disease in the following season. Unfortunately this plant was not grown for a second year, since the latent condition of the disease was not realised at that time and we do not know if the plant had really escaped infection.

The last six examples in Table I illustrate a latent condition of the disease which is linked with the barrenness† of propagants in the year following the division of the parent plant. In *Koeleria cristata*, *Festuca ovina* and *Holcus lanatus*, evidence that the non-fertile† plants were infected by the fungus was obtained by sectioning the barren tillers and finding in them the characteristic mycelium. The following year these plants were all potentially fertile and the fungus developed externally to the host. In *Festuca ovina* panicles were produced on first-year propagants which contained mycelium in the pith but showed no

* I am indebted to Mr J. R. W. Jenkins, Aberystwyth, for this identification.

† In this paper the words "barren" and "non-fertile" have been used exclusively for plants producing no inflorescences or potentially fertile tillers. They have not been used to indicate a condition resulting from the destruction of panicles by *Epichloe typhina*.

external symptoms of infection. This condition is frequent in *F. rubra* and will be referred to in Section IV (*c*).

Table II shows the degree of infection as estimated by the number of stromata upon the propagants of parent clones of *Dactylis*, which were previously grouped on a similar basis. The degree of infection in first-year propagants is not identical with that of the parent from which the propagant was taken. This no doubt is an indication of the uneven distribution of mycelium in infected plants.

Table I. *Showing the incidence of* Epichloe typhina *in the propagants of infected plants*

		One year after propagation			Two years after propagation		
Name of species	No. of propagants	No. of plants potentially fertile	No. of plants barren	No. of plants showing *Epichloe*	No. of plants potentially fertile	No. of plants barren	No. of plants showing *Epichloe*
Dactylis glomerata	287	287	0	286	—	—	—
Dactylis glomerata	12	12	0	12	—	—	—
Phleum pratense	4	4	0	4	—	—	—
Alopecurus pratensis	12	7	5	7	12	0	12
Agrostis stolonifera	15	10	5	10	15	0	15
Festuca rubra	8	3	5	3	8	0	8
Koeleria cristata	12	7	5*	7	12	0	12
Holcus lanatus	5	0	5*	0	5	0	5
Festuca ovina	4	3*	1*	0	—	—	—

* Microscopic examination showed mycelium in the vegetative organs; in *Festuca ovina* mycelium was present also in the pith of the inflorescence.

Table II. *Showing the incidence of* Epichloe typhina *in propagants of* Dactylis glomerata *classified according to the degree of visible infection in the parent plant*

		Degree of visible infection, 1929		
Degree of visible infection in five selected parent plants, 1928	No. of propagants	None	Some fertile tillers infected	All fertile tillers infected
None	15	15	0	0
Few fertile tillers infected	15	7	7	1
Many fertile tillers infected	15	0	15	0
All fertile tillers infected	14	2	8	4

It will be convenient at this stage to summarise the results of observations on single plants and propagants. The species named indicate those in which a particular fact has been recorded. *Dactylis glomerata* and *Festuca rubra* have been studied more fully than other species, but if a more extensive study were made upon other grasses most of the facts recorded might be found to have a more general application. There is definite evidence, however, that the disease is not biologically identical upon all hosts.

Conclusions drawn from observations on single plants and propagants

(1) Plants showing "complete infection" one season may produce some panicles in the next (*Dactylis glomerata* and *Festuca rubra*).

(2) Plants may produce both infected and non-infected fertile tillers for several consecutive seasons, but there is often a tendency towards "complete infection" in course of time (*Dactylis glomerata*).

(3) Plants very lightly infected one season may produce no visible infection in the following year (*Dactylis glomerata* and *Festuca rubra*).

(4) Plants which are barren for several years may contain the mycelium, ultimately become fertile and produce the disease (*Festuca rubra*).

(5) Plants which show "complete infection" are most likely to give infected plants when propagated, but some of the propagants may be at first more lightly infected than the parent (*Dactylis glomerata* and *Festuca rubra*).

(6) Propagants are often barren for the first year and so show no visible infection. Such plants are usually found to contain mycelium and to be visibly infected in the following year (*Koeleria cristata*, *Holcus lanatus*, *Festuca ovina* and *F. rubra*).

(7) Propagants may produce healthy panicles in the first year and show "complete infection" in the year following (*Dactylis glomerata*).

(8) Propagants may produce panicles which contain the fungus and yet show no visible infection (*Festuca rubra* and *F. ovina*). They may do this for several years and finally produce conidial stromata again (*F. rubra*).

IV. Invasion of the floral organs and transmission by the seed

(*a*) *Introduction.* The transmission of a disease by seed may result either by infection from within, mycelium entering the ovary from the stem, or by infection from without, spores falling on the ovary at flowering time. In this paper the term is used to indicate the first condition, the second alternative has not yet been investigated.

Distribution by seed as the result of systemic infection can obviously occur only when infected plants produce viable seed. In the disease caused by *Epichloe typhina*, the characteristic feature on which emphasis has usually been laid is the destruction of the inflorescence while still in sheath by the mycelium which produces on the surface the fruiting stage of the fungus. The study of a considerable bulk of material has shown, however, that individual plants vary in the extent to which flowering is prevented. The extremes of variation are indicated by the following grades, all of which have been met with in one or more species of Gramineae.

(1) "Complete infection," all inflorescences are destroyed by the

fungus (*Dactylis glomerata*, *Poa pratensis*, *Alopecurus pratensis*, *Holcus lanatus*, *H. mollis*, *Agrostis stolonifera*, *Koeleria cristata*, *Festuca rubra* (rare)).

(2) Some panicles are destroyed, others are exserted and healthy (*Dactylis glomerata*, *Poa pratensis*, *Holcus lanatus*).

(3) The majority of panicles are destroyed, but late inflorescences emerge and bear the conidial stage on few or many of the spikelets (*Dactylis glomerata* (rarely), *Holcus lanatus*, *Agrostis stolonifera*).

(4) Few or no panicles are trapped in the sheath; the majority emerge at the normal time, some bear the conidial stage while others are apparently healthy (*Festuca rubra*, *Poa bulbosa*).

(5) All panicles emerge and the plant looks normal. The parasite is present in the vegetative organs, in the pith of the inflorescence and in the flowers (*Festuca rubra*, *F. ovina*).

Transmission by infected seed has so far been proved only for *Festuca rubra*. Experience at Aberystwyth suggests that this is the normal method of distribution in this grass. The disease has occurred about half a dozen times at the Station, in cultures of red fescue collected for breeding purposes, but its origin has always been traced to samples of introduced seed. There is no evidence of the disease spreading by means of spores to healthy plants, and the "controls" used in experimental work have not contracted the disease, although growing by the side of infected plants. It has not been possible to show that the conidia which are abundant, or the ascospores which are rarely produced on this host, play any part in the spread of infection. Both types of spore are viable and grow readily in culture, producing colonies which vary only in their slower growth rate from those derived from the strains on *Dactylis glomerata* and *Alopecurus pratensis*.

Festuca ovina and *Poa bulbosa* have been studied as yet only to a limited extent, but it seems likely that transmission by the seed may also occur in these species. In *Poa bulbosa* failure to obtain viable seed from the panicles exserted by infected plants has probably been due to a lack of pollen, since healthy plants were not available at the right time.

Dactylis glomerata seems to stand in direct contrast to *Festuca rubra*, since it rarely produces panicles partially infected by the fungus. A considerable number of the inflorescences which do emerge from infected plants of *Dactylis* have been examined by the pith-scraping method, some seeds have been sectioned and others have been grown and allowed to flower, but the fungus has never been found and it is believed that such panicles have escaped all trace of infection*. The late inflorescences which sometimes emerge in this and other species with some spikelets destroyed and others seemingly healthy (grade 3)

* A single exception was found in June 1933. Pith taken from the base of a normal-looking inflorescence of *Dactylis glomerata* showed mycelium, while fresh strips of pith from the upper internodes gave on agar a pure culture of *Epichloe typhina*.

have not yet yielded viable seed. This may be due in part to the scarcity of pollen at the time the late panicles are in flower.

It seems that we have two contrasting forms of this disease, the one represented by that on *Dactylis glomerata*, in which ascospores are usually abundant and transmission by infected seed is absent or very rare, and the other typified in *Festuca rubra* with ascospores rare and seed transmission a normal occurrence. Probably intermediate types will be found in other grasses or even in different strains of these species. It is not yet known whether the contrast is due to divergent strains of the parasite or to differences inherent in the species of grass attacked or to both causes acting together.

(*b*) *Invasion of the flower and seeds and seedlings.* In discussing the invasion of the vegetative organs, reference was made to the occurrence of mycelium of *Epichloe typhina* in the pith of the axis of the inflorescence of *Festuca rubra*. This mycelium passes into all parts of the flower, penetrating the rachilla, glumes, and pales, the filaments and anthers of the stamens and the various tissues of the ovary including even the branches of the style.

Individual infected plants of *Festuca rubra* vary so widely in the distribution and quantity of mycelium present in the floral organs that it is difficult to make a generalised statement. Stamens may be so heavily infected that pollen grains do not form, or on the other hand, the fungus may occur only in the anther walls and pollen production may be normal. Even in anthers which contain mycelium in the pollen sacs, some pollen mother-cells divide and produce healthy looking pollen grains.

A similar range of destruction has been found in the ovary. An example of severe injury is given by plant 409 (3) (2) from which 41 spikelets were examined, yielding 160 ovaries all of which were riddled with mycelium and abortive. In other specimens the ovaries appeared to be in good condition at the flowering stage, but ultimately they failed to give satisfactory grain. Some plants on the other hand gave a yield of viable seed practically equal to normal uninfected plants (see Table VIII).

In a very young ovary (Pl. II, fig. 3) the mycelium runs between the cells in the integuments and nucellus. As the embryo-sac enlarges and encroaches on the tissues of the nucellus, strands of mycelium are found lying actually within the embryo-sac (Pl. II, figs. 1, 2, 3). In half-developed ovaries and in mature grains the mycelium forms a loose and irregular network outside the aleurone layer, round the embryo, and it may penetrate the endosperm tissue (Pl. I, figs. 6, 7; Pl. II, figs. 7, 8). Many grains were investigated before the fungus was discovered in the embryo, but several clear examples of this have been observed (Pl. I, figs. 4, 5). The number of recorded embryo infections is considerably smaller than the number of seedlings or plants infected, and it is believed that infection can take place during

germination from intraseminal mycelium lying near the embryo. Attempts to isolate the fungus from infected seeds have not yet met with success.

Mycelium has been traced in the embryo of seeds which have been germinating on filter paper for three days and fifteen days (Pl. I, figs. 8, 9; Pl. II, figs. 5, 6), and in seedlings grown in soil for six weeks. The incidence of the disease in the progeny of various families of open- and self-pollinated plants, confirm the view that the fungus is systemic in red fescue and is distributed by infected seed. Table III gives a list of the different lots of material microscopically examined in connection with the work on transmission by the seed. The table shows that the invasion of an infected plant is very nearly complete, even in certain plants which show no signs of the fungus externally (923, 810). On the other hand, some plants (927 and eight other plants in family 526) gave consistently negative results and these are believed to be free from infection although they came from an infected parent. It is naturally difficult to be certain on this point, since plants might give a very high percentage of grains entirely free from the fungus, and yet carry a small amount of mycelium, but by a process of elimination in very large families nine plants were isolated which appear to have escaped infection from the parent.

Table III. *Showing the incidence of infection by* Epichloe typhina *in ovaries, seeds and seedlings of* Festuca rubra

Part of plant examined	Description of parent: visible infection present or absent	Reference to plants	Number examined	Number in which mycelium was found
Ovaries at different stages	Present	940	16	16
	Absent	923; 810	21	21
	,,	927	18	0
Mature seed	Present	956	10	9
	,,	958	13	10
	,,	912A	3	3
	,,	957	5	0
	,,	S 1; S 16	16	16
	Absent	6 plants from 526 family	7	6
	,,	8 plants from 526 family	58	0
Seedlings 3 days old	Present	956; 958	13	4
Seedlings 15 days old	,,	S 1; S 5	11	4
Seedlings 6 weeks old	,,	526 family	17	17
Festuca rubra (control)	Absent	421 (1) and others	13	0
Festuca elatior	,,	—	5	0
Dactylis glomerata	Present	Various	39	0
	Absent	Various	10	0

Material was examined also from some of the plants used as "control" and from a plant of *Festuca elatior* in order to see if the fescues resembled the rye grasses in possessing a systemic fungus not visible

externally. The material of these "healthy" plants gave negative results*. Finally, reference should be made to the examination of ovaries from plants of *Dactylis glomerata* visibly attacked by *Epichloe typhina*. The negative results which were obtained on thirty-nine ovaries confirm the conclusions based on the examination of "pith-scrapings" that the panicles exserted by infected plants of cocksfoot do not normally carry infection.

(*c*) *The incidence of infection in the progeny of infected plants.* Seeds from three distinct sources, Pembrokeshire, Cornwall and Hertfordshire, have been used in studying the incidence of infection in the progeny of infected plants (Table IV). The first two samples (409 and 526) were grown originally by Mr T. J. Jenkin. Seeds were collected from single plants in 1925 and 1926, and their progenies were kept distinct throughout the work, but since individual plants gave substantially the same results the data have been pooled in the table. In so far as the transmission of this disease was concerned open- and self-pollination gave similar results (Table IV); the female parent is naturally the one which normally transmits the disease. It is not impossible that pollen might carry fragments of mycelium, since this is sometimes present in anthers which produce what seems to be normal pollen, but it is highly improbable that this method of transmission occurs frequently and it has not yet been proved.

The sample from Hertfordshire was collected by Mr A. Smith from panicles visibly attacked by the fungus. It provided additional evidence of seed transmission, but it was not used for detailed study.

It was necessary to conduct most of the work on plants growing in open ground, but a few seedlings were also raised in the laboratory and kept in a greenhouse until the disease appeared.

Other reasons have already been given for the belief that the fungus came from within and did not result from outside infection. Microscopic evidence of systemic infection, is also in complete agreement with this view.

The figures in Table IV recording the number of visibly infected plants are unquestionably high in some families, but there is ample evidence that they fall short of the actual degree of infection. A number of plants was selected from family 409 and broken up to form three propagants for further study. Many of these were barren in 1926 and none showed the fungus externally, but in 1927 the majority were fertile and many were visibly infected (Table V). Among 72 of the plants which showed no infection in 1925, 23 gave propagants which carried conidial stromata in 1927. Microscopic evidence was obtained that plants persistently barren, contained mycelium of the fungus, and it is not improbable that all plants coming from parent 409 were actually invaded by the parasite.

* See, however, Peyronel(19), and p. 44 of this paper.

Additional evidence of "latent infection," this time in fertile plants, was provided by family 526, which consisted in the first years (1926–9) of 790 plants. By eliminating those which showed visible infection, 16 apparently healthy plants were left in 1929. Ovaries and mature seeds were collected, fixed and microtomed, and examined for mycelium. When this was present in the first ovary the material was not examined further; if absent, at least seven seeds were cut before a negative result was recorded. By this method six plants were found to be positive and five of them confirmed this by producing conidial stromata in 1930. Nine plants were recorded as negative, and it is believed that they had escaped infection. Such a small number (1 per cent.) indicates the extensive distribution of mycelium in the plant and tallies with the microscopic evidence obtained from seeds

Table IV. *Showing the incidence of* Epichloe typhina *in the progeny of infected plants*

Reference to parent and method of pollination	Origin of seed	Year of observation	Total no. of plants	No. of barren plants	No. of fertile plants	No. of plants visibly infected	No. of plants visibly infected %
409: open	Pembrokeshire	1925	204	27	97	80	39·2
526: open	Cornwall	1926	749	508	241	4	0·5
„ open	„	1927	749	3	746	717	95·7
„ self	„	1926	44	43	1	0	0·0
„ self	„	1927	44	0	44	35	79·3
99: open	Healthy plant (control)	1927	16	1	15	0	0·0
1078: open	Hertfordshire	1932	19	0	19	10	52·6
Progeny of 409: self	Aberystwyth (1925)	1928	41	4	37	9	22·2
„ open	„	1928	1213	65	1148	280	23·1
917: open	Healthy plant (control)	1928	80	0	80	0	0·0

Table V. *Showing the incidence of* Epichloe typhina *in the propagants of selected plants in an infected family (Pembrokeshire,* 409)

Description of selected plants	No. of plants	No. of fertile plants 1926	No. of plants visibly infected 1926	No. of fertile plants 1927	No. of plants visibly infected 1927
Visible infection, 1925					
Panicles, few	17	0	0	11	6
Panicles, many	43	11	0	41	36
"Complete" infection	4	0	0	4	4
Total	64	11	0	56	46
No visible infection, 1925					
Barren plants	21	0	0	6	1
Fertile plants	51	3	0	42	22
Total	72	3	0	48	23

and seedlings. In this particular family (526) 100 per cent. infection was recorded in seedlings six weeks old (Table III).

(*d*) *Influence of the fungus on the host.* The adverse influence of *Epichloe typhina* is obvious when, as in *Dactylis glomerata*, panicles are destroyed and little or no seed is obtained. The purpose of the present discussion is to consider its influence on a grass like *Festuca rubra* in which the destructive work of the fungus is not so clearly defined. A direct comparison between infected and non-infected plants in a cross-pollinated species must be made with caution since "strain" is clearly an influential factor, but a study of various families, infected and healthy, has led to the conclusion that the adverse influence of *Epichloe typhina* on *Festuca rubra* may show itself in the following ways:

(1) A high proportion of barren plants and abnormally wide variation in the number of panicles produced by fertile plants. In 1925 (family 409) panicle number per plant varied from 0 to 700; in 1927 (family 526) the range was 47 to 796.

(2) Exsertion of panicles may be spread over an unusually long period; in 1925 (family 409) it was continuous from May 21st to July 14th. The first panicles to be exserted are more likely to appear healthy than later ones.

(3) Decreased seed production. This is shown in the weight of seed produced, the proportion of "heavy" seed and the germination (Tables VI, VII, VIII). The depressing effect of the fungus on seed production is indisputable when average figures for a number of infected plants are under consideration, and it might be argued that

Table VI. *Showing the weight and the germination in soil of seed from plants of* Festuca rubra *infected by* Epichloe typhina

Origin of seed	Weight of seed obtained from 10 panicles in gm.		Number of seedlings obtained from 10 panicles	
Healthy plant (917)	1·11		159	
Infected plants:	Av. of 8 lots	Range	Av. of 8 lots	Range
(*a*) Panicles not visibly infected	0·28	(0·10–0·60)	41	(0–108)
(*b*) Panicles visibly infected	0·11	(0·04–0·14)	16	(0–97)

Table VII. *Showing the percentage of "heavy" seed and the germination of samples from plants of* Festuca rubra *infected by* Epichloe typhina

Origin of seed	No. of heavy seed %	Germination %*
Healthy plant (917)	69·2	70
Infected plants:		
(*a*) Panicles not visibly infected: 6 lots	15·6 (0·2–31·9)	26 (0–77)
(*b*) Panicles visibly infected	(1) 38·4	31
	(2) 0·5	—

* The germination tests were carried out by the Continental Method and on Copenhagen tanks. Only one set of 100 seeds of each sample was available for testing, and the seed was two years old when tested.

Table VIII. *Showing the purity and germination of the seed of* Festuca rubra *collected from plants having different grades of visible infection*

Grade of visible infection in parent	Number of samples	Purity %		Germination %
		Average	Range	
Severe, 1927	4	44·5	(24·5–72·5)	85 (60–96)
Mild, 1927	7	83·4	(68·3–91·9)	91 (77–95)
Absent 1927, but infection proved later	2	67·9	(59·7–76·1)	95 (92–97)
Probably free from infection	3	85·9	(80·5–90·3)	96

These tests were carried out at the Official Seed Testing Station. The impurities consisted almost entirely of "chaff" which was of course in these samples "light seed."

such an effect is only to be expected in a parasitic disease. It is, however, a point of considerable interest that individual plants show such remarkable variation in this respect and that the amount and quality of seed produced by certain individuals comes very near to the standard of a healthy plant free from infection. This fact is particularly well illustrated in the figures giving the range of variation in purity and germination (Table VIII), and it is undoubtedly important in connection with the efficiency of infected seed as a distributing agent of the disease.

Tests on a number of samples showed that the degree of visible infection in the parent was not a reliable index to the quantity of viable seed ultimately produced. Some plants which showed no external sign of the parasite produced seed of relatively low purity and germination. On the other hand, certain plants visibly infected gave a good yield of viable seed (Table VIII), and it is this positive result which should be emphasised since it is essential to the view that the disease in *Festuca rubra* is transmitted by means of seed which owes its infection to the parent plant.

V. Discussion

A study has been made of the propagants and progeny of individual plants of various species of grasses attacked by *Epichloe typhina*. As a pathogen this fungus possesses features of peculiar interest.

While the zone of infection in the host is particularly wide, extending in fact into all the vegetative parts, the external development of the fungus is strictly limited, occurring only on the fertile shoots. Reproduction of the host and fruiting of the parasite are thus closely connected. To this extent *E. typhina* resembles certain smut fungi, but it differs from these in the greater abundance of mycelial growth in foliage leaves, and the hyphae are more persistent in old stems.

Actual necrosis of tissue occurs when flowering stems are trapped in the sheath and destroyed by the fungus. This may be the fate of

every fertile tiller with consequent loss in seed production. On the other hand, flowering stems often escape this attack, remaining fertile and uninfected, while others carry the fungus in all the floral organs and produce infected seed which transmits the disease. This wide range in the apparent intensity of attack can be found in red fescue among the individuals of a single family, a fact which is probably linked to some extent with the marked inequality which often characterises the progeny of cross-pollinated species of grasses. The problem of biological specialisation has not yet been studied in connection with this fungus.

Of special interest are those infected individual plants met with in *Festuca rubra*, which betray no external sign of the fungus, thus illustrating an extreme condition of "latent infection" which is not common among pathogenic fungi. "Latent infection" is known in some of the smut fungi when highly resistant varieties of the host suffer initial infection and permit for a time the development of mycelium in their tissues, but extensive invasion such as we have described in *Epichloe typhina* including the ovary and embryo, finds no parallel among fungi which are acknowledged to be parasitic. The closest parallel, and one of considerable interest, is found in those plants of *Lolium temulentum* and *L. perenne* which contain a fungus persistently sterile and distributed with the seed. Attempts to isolate and cultivate this fungus have yielded usually negative results. Isolations which are believed to represent the fungus in question have been identified as *Fusarium* sp.(9), a smut(10) and a new species of *Alternaria*(1). No one has succeeded in effecting the synthesis of the grass and its endophyte and the lack of uniformity in the results of culture experiments leaves the identity of the organism still an open question.

A fresh study of the *Lolium* fungus has been undertaken with the direct object of comparing it with *Epichloe typhina*, but the work is not yet complete. Although the two show points of resemblance, a certain dissimilarity has also been noted and proof that they are identical is still wanting. Further discussion of the subject is reserved for a later paper. The comparison has even greater interest since Peyronel(19) investigating recently the ovaries of a large number of different grasses, found mycelium which he identified as the *Lolium* fungus in *L. perenne*, *Festuca duriuscula* and *F. spadicea*. This is the first record of the *Lolium* endophyte in *Festuca* species and it is impossible not to speculate whether Peyronel might not have found *Epichloe typhina* in the "latent condition." From his description there seems to be at least one small point of difference which may be important, namely the presence of small button-like haustoria which are not, in my experience, characteristic of *E. typhina*. The fungal invasion of seeds in such closely related genera as *Festuca* and *Lolium*, whether by the same or by completely different organisms, is undoubtedly of interest and deserves further study.

Since little has been said in the text regarding the economic aspects of *Epichloe typhina*, it should perhaps be stated in conclusion that the elimination of infected plants immediately they appear in cultures of plants required for seed production or breeding work offers a simple and apparently safe method of control. Plants introduced from elsewhere, and particularly those which come from old pastures, and are introduced in the vegetative state, should be closely watched, and if possible isolated until the disease has had chance to show itself. By such a process of elimination it has been possible at the Plant Breeding Station in recent years to keep the disease in check without appreciable loss of valuable pedigree stock.

VI. Summary

1. *Epichloe typhina* is an intercellular parasite, which penetrates the vegetative organs of grasses, over-wintering in the perennial parts by division of which it can be propagated. Its development external to the host coincides with the flowering period and is closely linked with the fertility of the host. A condition of "latent infection" in which there is no visible growth outside the host may persist for several seasons.

2. The fruitfulness of the fungus varies on different hosts. The disease is contrasted upon *Dactylis glomerata* and *Festuca rubra*, perithecial formation being relatively scarce on the latter.

3. From infected plants seemingly healthy panicles may emerge which carry the fungus in all their parts. In *F. rubra* such panicles have been found to yield viable seeds which contain the fungus in and between the pericarp and endosperm and, more rarely, in the embryo. These seeds give rise to infected seedlings and the disease reappears in mature plants.

4. Plants of *F. rubra* may be completely invaded by the fungus without showing external signs of infection or obvious loss in vitality or productivity. These plants offer a close parallel to those of *Lolium perenne* which are invaded by a fungus which is sterile and distributed in the seed. The possibility that the endophyte of *Lolium* is identical with *Epichloe typhina* is discussed.

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Grateful acknowledgment is made to the valuable help given in

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EXPLANATION OF PLATES I–III

Figures in Pls. I and II were drawn in outline under a camera lucida. I am indebted to Mr D. Walters Davies, Aberystwyth for photographs 1, 4 and 5 reproduced in Pl. III, and to Mr H. G. Osterstock, John Innes Horticultural Institution, for Nos. 2 and 3.

PLATE I

With the exception of Fig. 3, all the figures refer to *Festuca rubra*: *c* = coleoptile; *e* = endosperm; *m* = mycelium; *s* = scutellum.

Fig. 1. Leaf in longitudinal section with mycelium traversing the chlorophyll tissue. The leaf was cut in May from a plant which showed no visible infection by *Epichloe typhina* in 1929. × 500.
Fig. 2. Cells from a transverse section of a leaf. The mycelium is intercellular. × 560.
Fig. 3. Part of a young shoot of *Alopecurus pratensis* in transverse section with mycelium emerging from the leaf. × 500.
Fig. 4. Immature caryopsis of *Festuca rubra* in transverse section showing two pieces of mycelium in the embryo. × 55.
Fig. 5. Enlarged drawing of mycelium in Fig. 4. × 650.
Fig. 6. Mature caryopsis in transverse section. Mycelium present between coleoptile and scutellum. × 55.
Fig. 7. Mycelium in Fig. 6. × 500.
Fig. 8. Caryopsis fixed after germinating for 3 days at 22° C. Mycelium in plumule. × 55.
Fig. 9. Mycelium in Fig. 8. × 500.

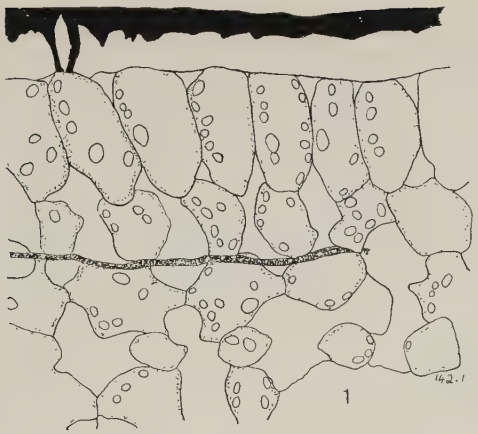
PLATE II

All the figures refer to *Festuca rubra*: *a* = antipodal cells; *a.l.* = aleurone layer; *e* = endosperm; *e.s.* = embryo-sac; *m* = mycelium; *p* = pericarp; *r* = root; *s* = scutellum; *v.b.* = vascular strand.

Fig. 1. Ovary fixed at the time of pollination showing mycelium on the edge of the embryo-sac. × 55.
Fig. 2. Nucellus from Fig. 1 enlarged. × 250.
Fig. 3. Young ovary in longitudinal section with mycelium in nucellus, integuments and ovary wall. × 55.
Fig. 4. Mycelium from the ovary of a plant with "latent infection." × 750.
Fig. 5. Seedling with old caryopsis still attached, fixed after growing for 15 days on damp filter paper. Mycelium is visible on either side of vascular strand in coleoptile. × 55.
Fig. 6. Mycelium from Fig. 5. × 250.
Fig. 7. Part of a caryopsis in longitudinal section showing mycelium between the embryo and the endosperm and in the pericarp. × 375.
Fig. 8. Mycelium penetrating between the starch-containing cells of the endosperm. × 500.

PLATE III

Fig. 1. Fertile shoots from a single plant of *Festuca rubra*. In No. 1, the panicle is trapped in the sheath; in No. 2, the panicle is exserted but covered by a conidial stroma; in Nos. 3 and 4, only a few spikelets are enveloped in mycelium, while No. 5 carries no "visible infection."
Fig. 2. Mycelium in the coleoptile of a seedling. (See Pl. II, figs. 5 and 6.)
Fig. 3. Mycelium in a longitudinal section of a leaf of *Festuca rubra*.
Fig. 4. Caryopsis of *Festuca rubra* in longitudinal section showing mycelium of *Epichloe typhina* outside the aleurone layer.
Fig. 5. Mycelium seen in surface view lying over the aleurone cells.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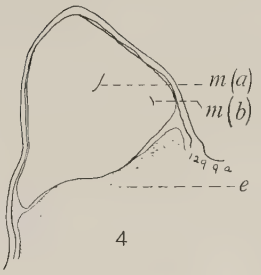
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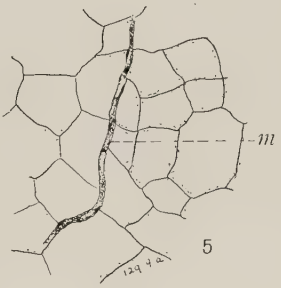
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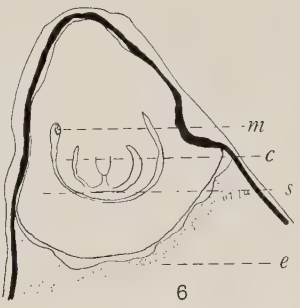
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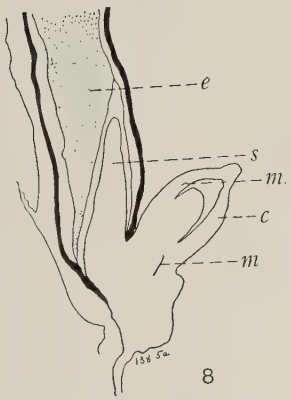
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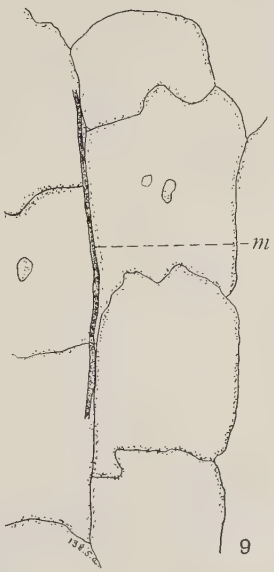
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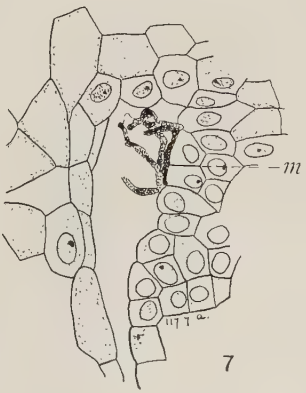
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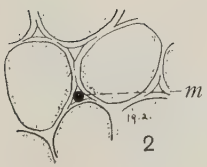
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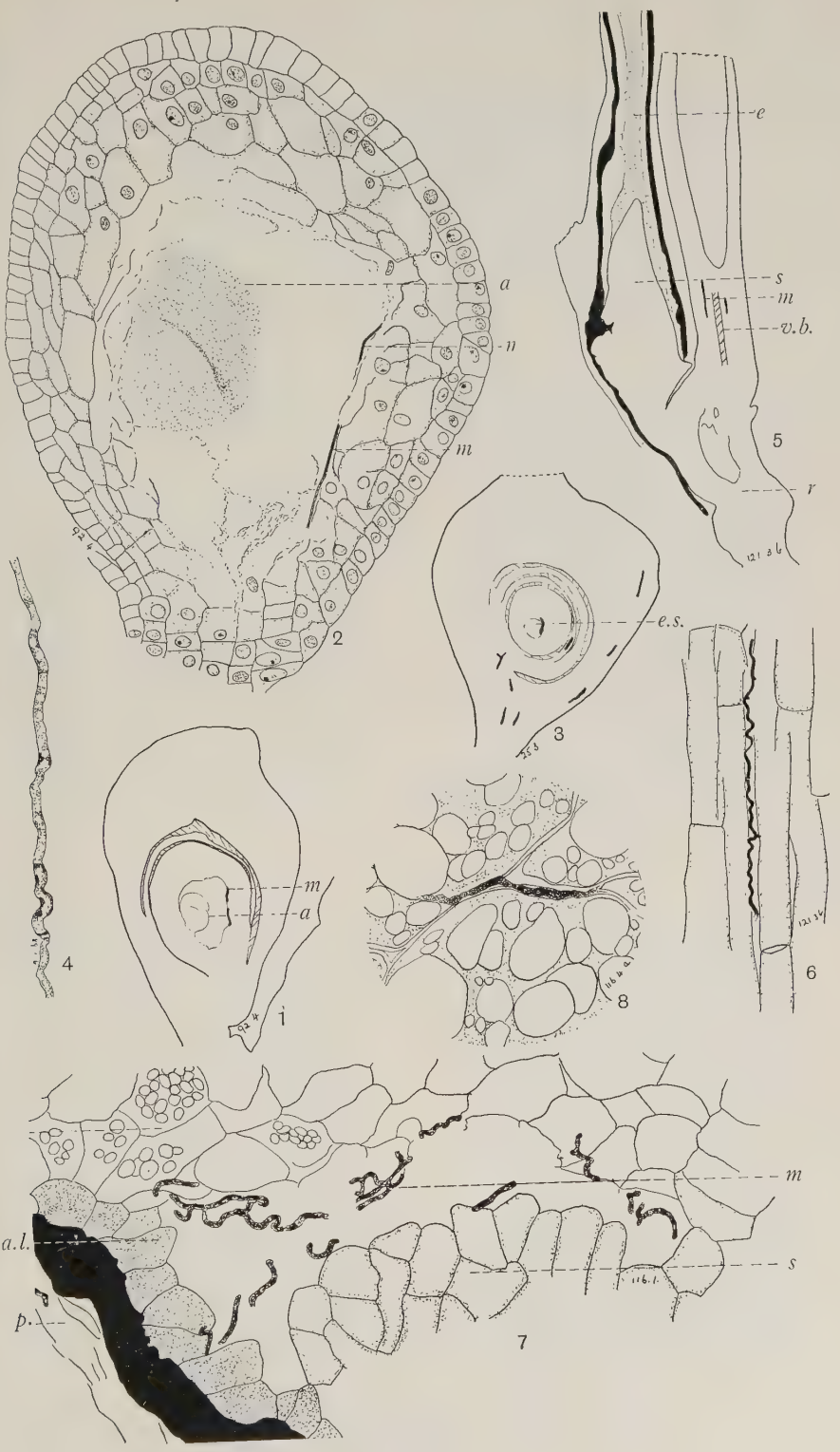
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Fig. 1

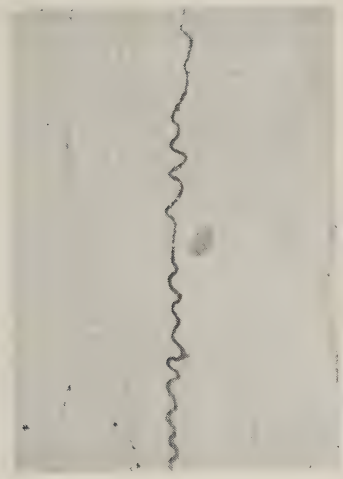

Fig. 2

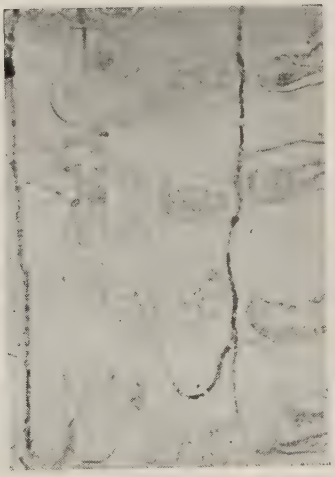

Fig. 3

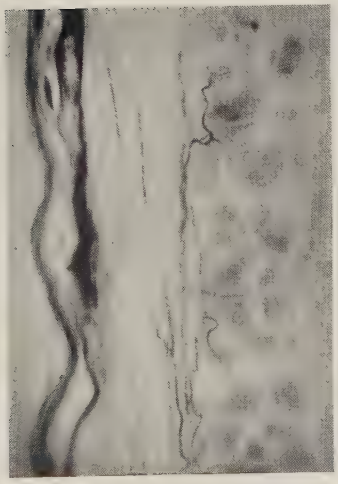

Fig. 4

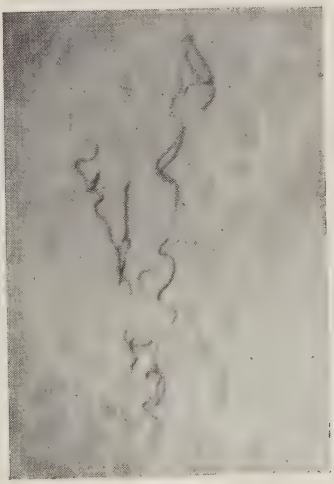

Fig. 5

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NOTES ON ENTOMOGENOUS FUNGI

By T. PETCH

49. *Cordyceps flavella* B. & C.

This species was described by Berkeley in *Journ. Linn. Soc.* x (1869), 375, as "Gregaria flavella; stipitibus filiformibus aequalibus pellucidis; capitulis globosis; peritheciis prominulis (519). Among leaves on wood, growing apparently from some sclerotium. December. About 1 inch high; stem filiform; head 1 line thick; asci slender. Allied to *C. myrmecophila*, Cesati."

The type specimen, now in Herb. Kew., consists of a single sclerotium bearing five filiform stalks, and one and a half detached heads glued to the sheet.

Saccardo, in entering the description in *Sylloge Fungorum*, II (1883), 569, added the note, "An reapse ex Sclerotio; an potius ex insecto in forman sclerotioideum abnormiter mutato?"

Cooke, *Vegetable Wasps*, etc. (1892), p. 228, wrote, "Two or three may be found growing together from the same matrix, and [in] a barren specimen, in which no heads have been produced, the stems are more elongated and flexuous, and ten or twelve together, with the appearance of an *Isaria*.... As to the *Sclerotium*, we imagine it to have been an error, as it is not so hard, or possessed of the internal character of a Sclerotium; it resembles rather the abdomen of some fly, or other insect, filled with mycelium, and the *Cordyceps* itself has a strong resemblance—a close affinity, at least—with *Cordyceps dipterigena*."

Cooke's figures show a cylindrical sclerotium, from which arise six filiform stalks, and two detached clavae with very much stouter stalks and smooth globose heads. They do not resemble the type in the shape of the sclerotium nor the character of the head.

Massee, in *Ann. Bot.* IX (1895), 9, redescribed *Cordyceps flavella*, and stated that the ascospores were filiform, with "component cells" about 4μ long, and that it grew from a "portion of a caterpillar."

Duss, in 1903, enumerated *C. flavella* from Guadeloupe, and there are numerous specimens of his collecting in Herb. Berlin. These agree with the type and are correctly named.

In general, each sclerotium bears a single clava. The head is subglobose or ovoid, about 1 mm. diameter, strongly echinate with projecting ostiola. The stalk is about 1 cm. high, 0·12 mm. diameter. A collar, about 0·25 mm. diameter and 0·1 mm. high, surrounds the apex of the stalk. In the herbarium specimens the head is now dark brown and the stalk pale red-brown, both subtranslucent. The asci

are very slender, 1·5–2 μ diameter, with linear, elongated, non-septate ascospores, 0·5–0·75 μ diameter.

The sclerotium is seated on, or surrounds, a grass spikelet, but does not completely hide or destroy it, the tips of the glumes usually being evident. They can be detected in the type on examination with a hand lens.

The fungus is evidently a *Claviceps*, and except in one particular it agrees with *Claviceps balansioides*, a species found by Möller on the spikelets of a *Panicum* in Brazil. The fungus itself, and the relation of the fungus to the host plant, agree completely with Möller's description, but he described the colour of the sclerotium of *Claviceps balansioides* as bluish black, whereas in the herbarium specimens of *Cordyceps flavella* the sclerotia are dark reddish brown, and the cortex is red-brown in section. It is probable, however, that Möller described the colour when fresh. There seems no doubt that *Cordyceps flavella* B. & C. (1869) is the same as *Claviceps balansioides* Möller (1901). It will now stand as *Claviceps flavella* (B. & C.).

In *Mycol. Notes*, No. 62 (February, 1920), 914, C. G. Lloyd stated that the Kew specimen of *Cordyceps flavella* was "mostly gone," but he found in Herb. Paris a nice specimen with two clubs which Berkeley had sent to Montagne. With it he correlated a recent Brazilian specimen from Rick on a caterpillar, and *C. incarnata* Möller. But Lloyd gave photographs of the Montagne specimen and Rick's specimen, which show conclusively that the two are different species. On one of the clavae of the Montagne specimen, as photographed, a collar is evident at the apex of the stalk, but it is clear that there is no collar on Rick's specimen. The latter is probably *C. incarnata*, which is quite distinct from *Claviceps flavella*.

50. *Cordyceps typhulaeformis* Berk. & Cooke

The type specimen of *Cordyceps flavobrunnescens* P. Henn. (1899) from Java, collected by Fleischer at Tjibodas, bears numerous clavae, usually with a clavate or cylindric head, but sometimes branching, the branches terminating in more or less globose clusters of perithecia. The perithecia are superficial, and do not always cover the clavate or cylindric heads, one side of which may be wholly or partly bare. The variation in the shape of the clavae is most extraordinary.

C. flavobrunnescens is apparently the same as *C. deflectens* Penz. & Sacc. (1897) from Java, judging from the figure and description of the latter. The figure shows a clava expanding upwards, giving off short sterile branches, and dividing above into two fertile branches, one with a thin cylindric stalk and a short cylindric head, the other expanding into a clavate, laterally flattened head, slightly incised at the apex. The perithecia are figured as free, scattered below and crowded above, though the figure of the section shows them immersed.

Both the above species appear to be the same as *C. typhulaeformis* Berk. & Cooke, from Java. The type specimen of the latter bears several small clavae, either clavate or cylindric. The perithecia are superficial and crowded, but usually absent over one side, or part of one side, of the clava.

C. mitrata Pat. (1898), from Java, described as having a one-sided clava and superficial perithecia, appears to be again *C. typhulaeformis*.

Cooke stated that *C. typhulaeformis* was red. The colour is now brownish yellow or dark amber, subtranslucent, and brownish yellow internally. There is no trace of red in mounted sections, and nothing to indicate that it was red when fresh. *C. flavobrunnescens* was described as brownish yellow. *C. mitrata* was described as pale reddish, from an alcohol specimen. *C. deflectens* was described as whitish, and this may have been seen by Penzig in a fresh state.

Penzig and Saccardo described *C. coccinea* on a beetle larva from Java. This is a bright red species, with immersed perithecia. Subsequently they described a var. *subochracea*, collected at Tjibodas in Java by Fleischer, which differed from the type in being ochraceous yellow, in having "more emergent" perithecia, and in growing on a lepidopterous larva. It is scarcely possible that this could be related to *C. coccinea*, and it would seem more probable that it was *C. typhulaeformis*. Von Höhnel (*Fragmente*, No. 209) recorded the same fungus from Java, under the name *C. subochracea* Penz. & Sacc.

51. *Cordyceps militaris* (Linn.) Link

The Tulasnes (*Sel. Fung. Carp.* III, Pl. I, fig. 28) figured the perithecia of *Cordyceps militaris* as superficial, and, in part, free from one another, and stated that they were seated on the club in a dense array. Saccardo (*Sylloge Fungorum*, II, 572) stated that the perithecia were subsuperficial. Winter (*Rabh. Krypt. Flora*) described them as more or less superficial. Seaver (*Hypocreales North America*) stated that the perithecia were "thickly scattered or crowded, for the most part immersed with the necks protruding, or superficial (especially in weathered specimens)."

In fresh specimens of *C. militaris*, the clava is minutely rough with the rounded apices of the perithecia. The perithecia are then immersed. As the clava dries, the context shrinks, the perithecia become more prominent, with conical or acute apices, and the outer layer of the clava dries into a thin, yellowish, matted layer of hyphae. If the perithecia are crowded, this layer persists almost continuous, and may be seen between the ostiola under a low magnification, though it may break up at the lower edge of the head, with the result that the perithecia there become free and apparently superficial.

On large clavae with scattered perithecia, the latter may be up to 0·25 mm. apart, and, in the dried specimen, united at about half their

height by a yellowish, byssoid sheet of hyphae, which is sometimes continuous, sometimes interrupted and lacking between adjacent perithecia or represented by a few hyphae only. The perithecia may then be for the most part superficial.

Thus, the perithecia of *C. militaris* are at first immersed, but may become superficial in dried or weathered specimens.

It has been customary to attempt to make a primary division of the genus *Cordyceps* into species with perithecia superficial and species with perithecia immersed. Saccardo divided the entomogenous species into those with perithecia "subimmersed" and those with perithecia "subsuperficial." But in the latter section he included both *C. militaris* and *C. Robertsii*, two species of totally different structure.

In some species of *Cordyceps*, *e.g. C. dipterigena*, *C. unilateralis*, *C. sphecocephala*, the perithecia are immersed. In these, the head has a definite cortex, and although the ostiola may project when the specimens are dry, the cortex remains continuous over the perithecia. In other species, *e.g. C. Robertsii*, *C. acicularis*, *C. falcata*, the perithecia are definitely superficial and free from one another laterally.

There is, however, a third group, represented by *C. militaris*, in which the perithecia are at first immersed, but become more or less superficial in dried specimens. *C. pruinosa* falls into this group. Many other species should apparently be classed with these, but it is somewhat difficult to decide from herbarium specimens, as their perithecia usually separate readily in section, and the remains of the outer layer, between their apices, may be obscure.

52. *Cordyceps miryensis* P. Henn.

This species was described by Hennings from specimens on the chrysalis of a Lepidopteron from Brazil. It was said to have yellow cylindric clavae with slender stalks and immersed perithecia, and to be near *Cordyceps typhulaeformis*. The latter species, however, has superficial perithecia.

In the type specimen, the example examined by me was 9·5 mm. high, with a stalk, 5 mm. long, 0·3 mm. diameter, and a narrow-cylindric head, 4·5 mm. long, 0·85 mm. diameter, with an obtuse apex. The stalk was dark red, subtranslucent, and the head pale yellow, fibrillose between the ostiola, which were amber translucent. The perithecial wall was red-brown. The part-spores, as measured from the septa of the ascospore, were $3–6 \times 1\,\mu$.

The structure of this species is the same as that of *C. militaris*. The perithecia are evidently immersed when the clava is fresh, but, when dry, the tissue between the perithecia becomes loosely fibrillose. Except in its deeper colour, *C. miryensis* does not differ from *C. militaris*.

53. *Cordyceps pruinosa* Petch

Ceylon specimens of a *Cordyceps*, which had been referred to *C. militaris* by Berkeley and Broome, were described by me as *C. pruinosa* in *Trans. British Mycol. Soc.* x (1924), 38. According to Thwaites, they were bright crimson when fresh. The structure of this species is apparently the same as that of *C. militaris*, but the tissue between the perithecia is dark red in the dried specimens and the stalks are also covered with red tomentum.

The immature clavae are linear or narrow clavate, crimson, strongly longitudinally fibrillose. This immature stage was described by Berkeley and Broome as *Anthina cinnabarina*.

54. *Cordyceps polyarthra* Möller

From a specimen (Möller 28E) in Herb. Berlin, *Cordyceps subpolyarthra* P. Henn. (1902) appears to be synonymous with *C. polyarthra* Möller. The specimen, however, is on a larva in a boring in wood, whereas Hennings described his type as "in foliis Musacearum."

C. concurrens Lloyd (*Mycol. Notes*, No. 68, January, 1923, p. 1180, Fig. 2370) appears from the photograph to be *C. polyarthra*.

The type of *C. caespitoso-filiformis* P. Henn. (1902), from Brazil, is immature *C. polyarthra*.

C. fasciculata Pat. (1899), collected by Duss in Guadeloupe, is represented in Herb. Berlin by Duss 75, which is a fragment of bark with the bases of two clavae. These would agree with *C. polyarthra*, but little can be determined from this specimen and Patouillard's description lacks essential details.

Isaria Dussii Pat. was also described from specimens collected by Duss in Guadeloupe. A specimen (Duss 1705) in Herb. Berlin is marked *I. curvispora* Pat. The clavae are small, simple below, expanding upwards and dividing into spreading branches about 0·1 mm. diameter, which bear long, scattered, spreading conidiophores, after the manner of a *Gibellula*. These conidiophores have smooth, septate stalks, about 2 μ diameter, and divide at the apex into a few short branches of cuboid cells, about $3 \times 3\mu$, which bear conoid phialides, $5 \times 2\mu$, the whole forming a globose head about 30 μ diameter. The conidia are oblong-oval, curved in one aspect, ends obtuse, $3–4 \times 1{\cdot}5–2\mu$.

Isaria palmatifida P. Henn. is a larger development of *I. Dussii*. It has the same conidiophores and conidia. Some of the clavae appear simple, having only a few, short, fasciculate branches at the apex.

I. amoene-rosea P. Henn. (1902) has the same type of structure, but its conidia are smaller, being oval, ends obtuse, $2–2{\cdot}5 \times 1\mu$, or globose, 1·5 μ. Hennings, however, stated that they were cylindric-oblong, $3{\cdot}5–4{\cdot}5 \times 1{\cdot}5\mu$.

This type of *Isaria* appears to be common in the tropics. A similar

species with curved conidia occurs in Ceylon, and one in Japan has been named *I. japonica* Yasuda.

Gibellula eximia v. Höhnel (1907) and *Isaria palmatifida* P. Henn. (1902) are the same as *I. Dussii* Pat. (1900), and are the conidial stage of *Cordyceps polyarthra*. It is not a *Gibellula*.

55. *Cordyceps clavulata* (Schw.)

This species, which attacks scale insects, is fairly common in the United States of America, and has occurred several times in Europe. It had been found only once in England, when it was named *Cordyceps pistillariaeformis* by Berkeley and Broome. The asci are narrow clavate, 80–100 × 8–10 μ, and the ascospores are given by Seaver (*Hypocreales of North America*) as elongate, subfiliform, broader near the base, and tapering to either end, 50–80 × 3 μ, seven to eight septate. The fungus is evidently *Ophiocordyceps*, and must stand as *Ophiocordyceps clavulata* (Schw.), comb. nov.

The conidial stage, which has the appearance of a *Stilbum*, was described by Jaap as *Isaria lecaniicola*. The clavae in the type are white or ashy, cylindric or clavate, 2–4 mm. high and about 0·3 mm. diameter. They are densely covered with phialides, which have an ovoid or conoid base bearing a stout sterigma, 5–7 μ long, or sometimes two or three sterigmata. The conidia are narrow-oval, or oblong-oval, or clavate, 3–7 × 1–2 μ. There is a slight covering of mycelium over the scale insect, and this bears the same phialides. Jaap gave the dimensions of the conidia as 5–8 × 2–3·5 μ. The conidial stage is the same in both European and American examples. It is a *Hirsutella*, which will stand as *Hirsutella lecaniicola* (Jaap), comb. nov.

56. *Cordyceps Doassansii* Pat.

This species was described by Patouillard in *Tabulae Analyticae Fungorum*, p. 213, Fig. 494. Patouillard stated that the head was 5–8 mm., and that was translated in Saccardo, *Sylloge*, as 5–8 mm. thick, but it is evident from the figure that Patouillard intended 5–8 mm. high. On the figure, which is said to be natural size, two clavae have heads 2·5 and 3 mm. long, with a total height of 3·5 and 4 mm. respectively. The stalk was said to be very short, or up to 1 cm. long. On the figure, the stalks of the two clavae already referred to are short, but another, apparently immature, clava is shown, which has a total height of 1 cm.

Patouillard's specimen was evidently immature. He did not give the dimensions of the ascospores, but stated that they were filiform, very long, and not septate. In Saccardo, they are said to be 90 × 45 μ. The latter is obviously a misprint for 4·5 μ, and both measurements were probably derived from Patouillard's figure.

In the original description the conidia were given as spherical,

1·5–2 mm. It is evident that this is a mistake for 1·5–2 μ. Several similar mistakes occur in succeeding descriptions. Thus, *Gnomonia Gei* Pat. & Doass. is said to have asci, 26 × 5 mm., and spores, 12–14 × 1 mm., while for *Leptosphaeria silenes-acaulis* de Not. the dimensions of the asci are given as 40–50 mm., and the spores as 30 × 6 mm. In Saccardo, the conidia of *Cordyceps Doassansii* are given as 4·5–5 μ diameter, which again is probably a measurement from Patouillard's figure.

The conidial stage was said to consist of a stalk, 5–8 mm. long, with a floccose head. The figure shows two of these clavae, with stalks about 3 mm. long, expanding into a flattened-globose head, 4·5 mm. wide.

Cooke (*Vegetable Wasps*, etc.) remarked that the conidia, though called sphaeroid, were said to measure 4·5 × 2 μ, but whence he derived that measurement is unknown.

It will be seen that there are numerous errors in the various accounts of this species, although all are based on Patouillard's original description and figures. Even Patouillard's description does not agree with his figure, as regards dimensions. It is perhaps not surprising that the fungus has not been recorded again, and a re-examination of the type is highly desirable.

Meanwhile, it may be pointed out that the figures of the perithecial clavae bear a striking resemblance to *C. clavulata*, and the figure of the insect resembles a scale insect rather than a pupa. Cooke's reproduction has been improved, in the latter respect, to fit the text. But the clavae of *C. clavulata* are not recorded as more than 3–4 mm. high, and the conidial stage of the latter species is quite different from that figured for *C. Doassansii*. Nevertheless, it would seem worth while to examine the type with that resemblance in mind. It is perhaps merely a coincidence that the measurement of the conidia given by Cooke would fall within the range of the conidia of *C. clavulata*.

57. *Cordyceps entomorrhiza* (Dicks.) Link

This species was first described by Dickson (as *Sphaeria*) in 1785 from specimens found at Bulstrode, Bucks. Berkeley, in 1836, published a redescription, but his specimens were not Dickson's fungus, but *Cordyceps gracilis* Mont. & Dur. In consequence, British mycologists during the last century recorded *C. gracilis* under the name *C. entomorrhiza*. Dickson's species occurs on beetles and beetle larvae, whereas *C. gracilis* occurs on lepidopterous larvae.

The Tulasnes published figures of "*Cordyceps entomorrhiza*," based on specimens from Broome which were really *C. gracilis*, and a specimen from the Pyrenees which was the true *C. entomorrhiza*. At the same time they described as *Torrubia cinerea* a specimen found near Paris, which was again the true *Cordyceps entomorrhiza*. Hence *C. entomorrhiza* (Dicks.) Link came to be known as *C. cinerea* on the continent of Europe. In 1897, Quélet described it again as *C. Carabi*.

Specimens found in herbaria under the name *C. entomorrhiza* are usually either *C. gracilis*, or *C. sphecocephala*, or *C. Ditmari*.

C. entomorrhiza has not been found again in this country, though it has been recorded several times on the Continent. Large collections of it were made near Leipzig in 1866 and 1867 by Auerswald and Delitsch, and these were issued in Rabenhorst, *Fungi Europaei*, Nos. 1010 and 1218. The host was *Carabus nemorensis*. Further examples were issued in Rehm, *Ascomyceten*, No. 1288.

It has been suggested that *Isaria Eleutheratorum* Nees is the conidial stage of *Cordyceps entomorrhiza*, and Schroeter (*Krypt. Fl. Schlesien*), acting on that supposition, changed the name of the latter to *Torrubia Eleutheratorum*. But, as previously shown (*Naturalist*, February, 1932, p. 45), Nees's species is a *Hirsutella*. There should, however, have been no doubt about the conidial stage after the collections of 1866, for these contain both the perithecial and the conidial stages, the latter in abundance.

The conidial clavae arise from the larvae either singly or in groups of up to a dozen. In general, they are about a centimetre long, linear, terete or irregularly flattened, simple, or expanded and branched at the apex, brown, becoming black, whitish towards the apex. Each clava or branch terminates in a small subglobose, or ovoid, or laterally flattened head, the shape of the head depending upon that of the stalk. Sometimes a larva bears one long clava, instead of numerous shorter ones. In one example, the insect bore a clava, 6 cm. high, slender below, expanding upwards and bifurcating at the apex into a flabelliform lobe on one side and a repeatedly branched stem on the other, the ultimate branches being slender and bearing small conidial heads.

Conidial clavae also occur as lateral branches on the stems of the *Cordyceps* clavae, and thus establish the relationship between the two forms.

The head is waxy, and pale yellow or pale brown in the dried specimens. The conidiophores are linear, simple or branched, 24–40 μ high, 0·75 μ diameter, arising in clusters from the apices of the stalk hyphae and forming a compact head. The conidia are terminal, minute, hyaline, oval, oblong-oval, or subpyriform, 1·5–3·5 × 0·75–2 μ, or globose, 1–2 μ diameter.

This conidial stage of *Cordyceps entomorrhiza* is a *Stilbella*. It is apparently the same as *Clavaria setiformis* Vahl, recorded by Vahl in 1793 (*Naturhist. Selsk. Skrivt.* II, 50) from specimens on *Carabus hortensis*. Vahl's comparison with (immature) *Xylaria Hypoxylon* is apt, and quite unsuitable for *Hirsutella Eleutheratorum* (Nees) Petch. I name it *Stilbella setiformis*.

Stilbella setiformis (Vahl) Petch; *Clavaria setiformis* Vahl. Clava lineari, recta vel torta, tereti vel hic illic complanata, laevi, brunnea

dein nigra, supra pallida, simplici vel furcata, interdum supra flabelliformi; capite subgloboso, ovoideo, vel a latere compresso, ceraceo, pallide flavo vel brunneo (sicco); conidiophoris linearibus, simplicibus vel ramosis, radiantibus, confertis, 24–40 μ longis, 0·75 μ diam.; conidiis apicalibus, minutis, hyalinis ovalibus, oblongo-ovalibus vel sub-pyriformibus, 1·5–3·5 × 0·75–2 μ, vel globosis, 1–2 μ diam.

As previously pointed out (*Naturalist, loc. cit.*), Saccardo, in describing a fungus on a beetle (*Apion*) which he took to be *Isaria Eleutheratorum* Nees, gave a figure showing a terminal *Stilbella* head. That does not agree with Nees's figure of *Isaria Eleutheratorum*, nor with the specimens which Saccardo issued under that name in *Mycotheca Italica*, No. 1397, on *Apion*. It would seem possible that the figure represents *Stilbella setiformis*, but the spore measurement given by Saccardo, 6–7 × 3·5 μ, is much greater than that found in the examples in Rabenhorst, *Fungi Europaei*, No. 1218.

In 1930, Yakushiji and Kumazawa, in Japan, described *Isaria nigra* on beetles and beetle larvae (*Bot. Mag. Tokyo*, XLIV, 40–2). Their description fits *Stilbella setiformis*, though they did not describe the structure of the head. The conidia were said to be 3·5–5 × 0·8–0·9 μ, but in a later communication (*op. cit.* p. 204) that was corrected to 7–10 × 2 μ. It would be interesting to have further confirmation of that, as *Isaria nigra* appears to be much too close to *Stilbella setiformis* to be distinct.

58. *Cordyceps Glaziovii* P. Henn.

In *Phycomyceten und Ascomyceten*, p. 229, Möller recorded *Cordyceps entomorrhiza* for Brazil. In his idea of *C. entomorrhiza*, Möller was following British mycologists, and the species he had in mind was really *C. gracilis* Mont. & Dur.

Möller noted that there was no mycelium at the base of the stem in his specimens, as there usually is in *C. gracilis*. The colour of the whole fungus was "lehmbraun," with a slight reddish tinge on the head of one specimen, and the walls of the embedded perithecia were darker than the context. The part-spores were 12 μ long.

Möller's figures show a general resemblance to *C. gracilis*; but his fungus differs from that species in the absence of free mycelial strands at the junction of the fungus and the host, in its position on the host, in colour, in length of part-spores, and in the fact that it grew on beetle larvae.

Hennings, in 1897, described *C. Glaziovii* from a specimen collected by Glaziou in Brazil. Hennings stated that the stalk was pallid and the head red-brown, and (with a query) that it grew on a lepidopterous larva. The type specimen is on a beetle larva, and the fungus appears to be the same as that attributed by Möller, in error, to *C. entomorrhiza*.

Lloyd (*Mycol. Notes*, No. 62, p. 912), discussing *C. gracilis*, stated "There are only two collections of this known to me from the States. One is in Peck's collection, and the other was developed in culture at New York from material sent from Indiana." From his photographs, these appear to be *C. Glaziovii*, rather than *C. gracilis*.

Ravenel collected specimens in South Carolina, which were assigned to *C. entomorrhiza*, *i.e. C. gracilis*. Two collections, Ravenel 768 and 956, are now in Herb. British Museum, and one, marked by Berkeley "No. 2613, Car. Inf. Ravenel. *Sphaeria entomorrhiza*," in Herb. Kew. The latter appears to be a half of one of the specimens in Ravenel 956. Ravenel named No. 768 *S. ophioglossoides*, and No. 956 *S. capitata*, but he subsequently altered both names to *Cordyceps entomorrhiza*, with a reference to *Grevillea*, IV, 13, where Ravenel 2613 is recorded under that name.

Ravenel 768 is evidently *C. ophioglossoides*, and No. 956 is apparently the same, though the specimens have not turned black, perhaps because, as stated by Ravenel in an accompanying note, they were "found in a very dry spell of weather." The part-spores of No. 956 were measured by Ravenel as 2·5μ long, which agrees with *C. ophioglossoides*. Lloyd (*loc. cit. supra*) referred Ravenel's specimens to the latter species.

There are no known specimens of either the true *C. entomorrhiza* or of *C. gracilis* from America. The record of *C. gracilis* for Ceylon in *Trans. British Mycol. Soc.* X (1924), 30 is also incorrect.

Berkeley described a specimen from Australia as *C. menesteridis* Muell. & Berk. Cooke (*Vegetable Wasps*, etc., p. 169) referred this to *C. entomorrhiza* as var. *menesteridis*. It is, of course, not in the least like *C. entomorrhiza*, though it has a resemblance to *C. gracilis*. As, however, it has no mycelium at the base of the stem and is on a beetle larva, it should be left under Berkeley's name. It resembles *C. Scottiana* Oliff, but lacks the abundant mycelial strands of the latter.

59. *Cordyceps martialis* Speg.

Cordyceps martialis was described by Spegazzini in 1889 from specimens on the larva of a beetle in rotten wood, found at Apiahy, Brazil. Spegazzini described it as "aurantius," but, as pointed out by Möller (*Phycomyceten und Ascomyceten*, p. 219) in connection with *C. australis*, Spegazzini's "aurantius" is "miniatus." The clavae arose from a furfuraceous-squarrulose mycelium which covered the whole host insect, but the colour of that mycelium was not recorded.

Möller found commonly in Brazil a *Cordyceps* on beetle larvae which Hennings described (1896) as *C. submilitaris*. Hennings stated that the clavae were "aurantiacus," and arose from a pallid effused membranous mycelium. But Möller's coloured drawing in Herb. Berlin shows both the mycelium and the clava cinnabar.

It seems most probable that *C. submilitaris* is the same as *C. martialis*. The only marked difference between the descriptions is in the shape of the perithecia, which in *C. martialis* were said to be "globulose," with a long conical neck, while Möller described those of *C. submilitaris* as narrow pyriform. But Möller remarked that, as the perithecia were oblique to the surface, it was not possible to see a complete longitudinal section of a perithecium in a cross-section of the clava, but only in a longitudinal section. The only known *Cordyceps* with globose perithecia is *C. palustris* B. & Br. In that species the perithecia have a short neck, and the fungus differs in colour, shape, and part-spores, from *C. martialis* as described.

Lloyd, in 1920, recorded *C. Rickii* on beetle larvae from Brazil. Its colour was said to be Mars yellow when dry, but probably more orange when fresh. Lloyd stated that he could not make it fit *C. submilitaris*, but nevertheless it appears to be that species, as far as can be judged from the figures.

I have examined a specimen of *C. submilitaris* from Trinidad, collected by W. E. Broadway, January, 1908. The clava and the mycelium on the insect were cinnabar, and the perithecia were embedded in a peripheral black layer. Lloyd's photograph of the cross-section of *C. Rickii* appears to show the same black layer. It is curious that the three descriptions omit the most peculiar features of the fungus, viz. the highly coloured mycelium, and the black peripheral layer of the head.

60. *Cordyceps acicularis* Rav.

In *Journ. Linn. Soc.* 1 (1857), 157–9, Berkeley described *Cordyceps acicularis* Rav. and *C. Ravenelii* Berk. & Curt. The former was a slender species, with a cylindric head which terminated in a sterile apex. The latter was stouter, with a cylindric head, attenuated above. Both had superficial perithecia. Berkeley stated that *C. acicularis* is "closely allied to *Cordyceps Ravenelii*, but the habit is very different; I can find no essential difference in the fruit." It is not clear what Berkeley meant by "habit"; in his figures, *C. Ravenelii* has a stouter stalk and head, and the elongated subcylindric head lacks a sterile tip and has an obtuse apex.

C. Ravenelii was Ravenel 1272, and *C. acicularis*, Ravenel 1276. In Herb. Kew. there is a specimen of No. 1272, marked by Ravenel, "Looks like a variety of 1276." The No. 3080, cited first by Berkeley for *C. Ravenelii*, was the number placed by Curtis on a part of No. 1272 sent to him by Ravenel. Hence the citation of "Berk. & Curt." for *C. Ravenelii*.

Berkeley stated that *C. acicularis* grew on caterpillars, and *C. Ravenelii* on beetle larvae, *Ancylonycha* Dejean on *Rhizotrogus* Latreille. Ravenel, however, had written that *Cordyceps acicularis* grew on larvae.

Cooke (*Vegetable Wasps*, etc., p. 214) placed *C. acicularis* among the species parasitic on Lepidoptera, stating that the insect was difficult of determination, and Mr Gray could not say to what family of Lepidoptera the larvae belonged. But on consulting Gray's *Notices*, it is found that Gray wrote (p. 13), "The Rev. Mr Berkeley has recorded that in South Carolina were obtained, during summer, certain small 'caterpillars' that were buried in the soil in damp woods....But not having seen specimens it is impossible from the figures to form any opinion as to the family of Lepidoptera they may belong to."

Thus, Gray had not seen any specimens. At the time he wrote, the numerous specimens now in British herbaria were in the private herbaria of Berkeley, Ravenel, and Broome, and he judged merely from the published figures. Ravenel stated that *C. acicularis* grew on larvae, and the specimens now available in the herbaria of Kew and the British Museum show that it grew on beetle larvae.

It is evident from the foregoing that Gray's *Notices of Insects that are known to form the Bases of Fungoid Parasites* is not so authoritative as has been supposed, as it is compiled, in great part, from published records only.

One macroscopic difference between *C. Ravenelii* and *C. acicularis*, as illustrated by Berkeley's figures, is the difference in the diameters of the clavae. But, as previously noted by Massee (*Ann. Bot.* IX, 34), *C. Ravenelii* is very variable in that respect, "some specimens being tall and robust, others extremely slender." On the dried herbarium specimens, *C. Ravenelii* varies from 1·5 to 4·5 mm. in diameter, while *C. acicularis* is up to 1·75 mm. diameter.

Another difference, judging from the figures and descriptions, lies in the barren apex of *C. acicularis*. As regards that, Massee (*loc. cit.*) wrote: "The apex of the head is not sterile, but as in other species with superficial perithecia these readily fall away when mature, and had done so from the apex of the head in the specimen described by Berkeley, but in several other specimens of the same species the head is completely covered with perithecia."

Massee's explanation is a deduction from the herbarium specimens, and unfortunately he interpreted them the wrong way. In the Ceylon species attributed to *C. falcata*, the perithecia are superficial. The clava is usually falcate, and at first white and fibrillose, destitute of perithecia though of full size. The perithecia then arise in one or more groups, usually on the upper side of the clava, and increase in number until they may completely surround the clava and cover the upper part entirely. But, as generally collected, the clava bears separate patches of perithecia scattered over its surface.

Thus, the presence of a sterile apex is not necessarily a specific character in species of *Cordyceps* which have superficial perithecia. It may merely indicate that development has been arrested before the

perithecia had covered the clava. On the other hand, in a *Cordyceps* with perithecia immersed in a swollen region enwrapping the clava, as in *C. Barnesii* and *C. stylophora*, the presence of a sterile apex (of the same texture as the stalk) is probably of specific value, though it is not difficult to imagine that it may sometimes be wanting.

However, from the available herbarium specimens, that point does not arise, as between *C. Ravenelii* and *C. acicularis*. Of twenty-seven specimens of *C. Ravenelii* in British herbaria, nearly all from Ravenel, three have the apex broken, twenty have a naked (sterile) apex, three have the perithecia extending to the apex, and one has the perithecia extending to the apex on one side only. Owing to the greater thickness of the clava, the sterile apex is broadly conical and consequently is not so prominent as in *C. acicularis*, but it may be up to 5 mm. long.

The specimens of *C. acicularis* at Kew and the British Museum are comparatively poor, and most of them are now in fragments. Four certainly had a sterile tip, up to 9 mm. long, five are broken and the tips are missing or unrecognisable, while nine, some of them intact, have apparently not developed any perithecia.

In *C. acicularis*, the perithecia are now black, about 0·28 mm. high, 0·25 mm. diameter at the base, broadly conical or ovate, apex truncate, sometimes abruptly contracted towards the apex, minutely rough. The asci are narrow-clavate, 260–290μ long, 7–10μ diameter, with a capitate apex. Irregular, strap-shaped paraphyses are present, but diffluent. The ascospores are linear-clavate, tapering slightly towards one end, multiseptate, with septa 4–6μ apart, 150–240 × 3–4μ, not dividing into part-spores. They are not in a uniform bundle, but, in general, four spores reach the apex of the ascus, and four terminate some distance below. Of the latter, one, sometimes two, reach the lowest point of the bundle in the ascus. The fungus is thus *Ophiocordyceps*.

C. Ravenelii has exactly the same perithecia and spores. It seems clear that *C. acicularis* is merely a poor development of *C. Ravenelii*. The former name has page priority.

In the *28th Report N.Y. State Museum*, p. 70, Peck described *Torrubia superficialis*, a species which he stated was intermediate between *Cordyceps acicularis* and *C. Ravenelii*. It was found on buried larvae under hemlock trees. Seaver (*North American Flora*) referred this, with a query, to *C. acicularis*. That reference appears, from the description, to be correct. The synonymy of this species is as follows:

Ophiocordyceps acicularis (Rav.), comb. nov.; *Cordyceps acicularis* Rav. in *Journ. Linn. Soc.* I (1857), 158; *C. Carolinensis* Rav., in Ravenel, *Fungi Carol. exsicc.* No. 29; *C. Ravenelii* Berk. & Curt. in *Journ. Linn. Soc.* I (1857), 159; *Torrubia superficialis* Peck, *28th Report N.Y. State Mus.* p. 70; *Cordyceps superficialis* (Peck) Sacc. *Sylloge Fungorum*, II, 574.

Cordyceps ainictos Möller, as redescribed by Theissen (*Ann. Myc.* IX

(1911), 68), appears, from Theissen's figure, to resemble *C. acicularis*. Theissen, however, described the clava as sordid golden yellow, the perithecia as yellow-brown, conical, *with an acute apex*, and the spores as linear, with septa 10–11 μ apart. His description of the ascus as slightly clavate, 8 μ diameter, suggests *Ophiocordyceps*. The long clavae in the type of *Cordyceps ainictos* Möll. bear superficial perithecia with an acute apex; Möller described the clava as brown and the perithecia as brown to blackish, but found them all effete. The wall of the perithecium of *C. acicularis* is composed of polygonal cells, but these are not so regular, nor so thick-walled, as figured by Theissen for *C. ainictos*. These two species appear to be distinct.

61. *Cordyceps brasiliensis* P. Henn.

Cordyceps brasiliensis was described by Hennings in 1897 from a specimen from Rio de Janeiro, collected by Glaziou. The type is about 6 cm. high, and has a stout cylindric stalk, 2–3 mm. diameter. The head is clavate, 1·5 cm. high, shortly bifurcate at the apex, and there is a short conical lateral branch, 5 mm. below the head. The perithecia were said by Hennings to be "liberis, vel unilateraliter pulvinato-adnexis." They are immersed, but oblique, as in *C. sphecocephala*, not perpendicular to the clava. Hence the clava is somewhat ridged when in alcohol, especially at the base, each ridge containing a perithecium being regarded by Hennings as a laterally adnexed perithecium. Hennings stated that the asci were 4–5 μ diameter, and the ascospores 5–6 μ diameter, which is obviously impossible. These details cannot be amended, as the type is preserved as an exhibition specimen. Hennings apparently did not observe part-spores, and the specimen appears to have been immature. The colour was said to be pallid, as it is now in alcohol.

In 1900, Hennings described *C. olivaceo-virescens*, from specimens collected by Huber at Para. The colour was said to be "olivaceo-virescens," but the green is due, at least in part, to a covering of conidia of *Aspergillus* or *Penicillium*. When magnified, the clava is olivaceous, with discontinuous green patches. The stalk was described as forked at the base or at the middle, 3–3·5 cm. long, 1·5–2 mm. thick, and the head fusoid or cylindric, 1·5–2 cm. long, 2–3 mm. diameter. The perithecia are immersed, and their arrangement is the same as in *Cordyceps brasiliensis*. The perithecial wall is brown, the asci cylindric, 3 μ diameter, and the ascospores 0·75–1 μ diameter, with septa, 3–6 μ apart.

Lloyd, in 1922, recorded *C. olivacea* Rick, collected by Rick in Brazil. He stated that it was olive colour when fresh, and that the perithecia had projecting ostiola which were darker than the clubs. Hennings described the perithecia of *C. olivaceo-virescens* as "nigra."

Lloyd suggested that *C. olivacea* Rick was the same as *C. olivaceo-*

virescens P. Henn. That is no doubt correct, but both are the same as *C. brasiliensis* P. Henn. The fungus grows on beetle larvae.

62. *Cordyceps* on Bees and Wasps

Some of the species of *Cordyceps* on bees and wasps were discussed in note 29, *Trans. British Mycol. Soc.* XVI (1932), 219.

The first species recorded on a wasp was *C. sphecocephala* (Klotzsch) Cooke, from the West Indies, which has been known since 1754. Generally, this species has an ovate head, about 5 mm. high and 2–3 mm. diameter, as figured by the Tulasnes. Cooke's figure (*Vegetable Wasps*, etc., Fig. 11) quite misrepresents this species, and is apparently a bad copy of *Selecta Fungorum Carpologia*, III, Tab. 1, Fig. 9, at least as far as regards the insect, though the fungus bears some resemblance to a specimen, Glaziou 18778*a* in Herb. Kew., which was collected without its host and attributed, in error, to *C. sphecocephala*.

C. thyrsoides Möller is *C. sphecocephala*, and *C. lachnopoda* Penz. & Sacc., according to the description, differs only in having hairs on the stem. Further examination of the type of the latter is necessary, in order to ascertain the nature of these hairs.

Species on other insects which resemble *C. sphecocephala* in having an ovate acute head, *e.g. C. nutans* and *C. bicephala*, are known to vary and produce cylindric acute heads. This variation also occurs in *C. sphecocephala*, and is represented by *C. gentilis* (Ces.) Sacc. from Sarawak and the synonymous *C. oxycephala* Penz. & Sacc. from Java. The cylindric head may be 12 mm. long, 1·2 mm. diameter, with a thin tip of varying length.

C. Puiggarii Speg. was first recorded as *C. sphecocephala*, but was subsequently described as a new species by Spegazzini. It was described as a small form, with an elliptic-fusoid head, 1·5 mm. long, 0·5–0·6 mm. diameter, terminating in a rather long conical acute apex.

C. Humberti Robin, from West Africa, is apparently merely a small form of *C. sphecocephala*.

It would appear that all these species should be referred to *C. sphecocephala*.

C. Ditmari was described by Quélet as having an ovoid head and a stalk with a double collar at the apex. He wrote, "La cuticule forme parfois, en s'exfoliant, une double collerette fimbriée." His figure shows a subglobose head. The best specimens I have seen of this species are in Herb. Berlin, on wasps, collected by F. L. Sautermeister at Schörzingen, and issued as *C. entomorrhiza* in *Flora von Wurtemberg*. In these the whole fungus is now straw-yellow, and the head is ovate or subglobose, rounded above, up to 5 mm. high, 4 mm.

diameter. A collar, which is a downward extension of the outer layer of the head, surrounds the apex of the stalk, independent of any splitting of the cuticle of the latter. It resembles the collar in *C. flavella*.

I would retain *C. Ditmari*, as distinct from *C. sphecocephala*, because of its subglobose head, not acute above. The collar at the apex of the stalk does not appear to be a constant character. But *C. Ditmari* (1877) is evidently the same as *C. armeniaca* (1857), though the two detached clavae which constitute the type of the latter are poorly developed, with heads 0·9–1 mm. high and 1·2–1·6 mm. diameter, and apparently immature. Massee's redescription of *C. armeniaca* includes details of *C. dipterigena*, of which two collections, from Rangoon and Ceylon respectively, are included in the cover of the former species in Herb. Kew. *C. Langloisii* Ellis & Everhart (1892), *fide* Lloyd, is the same as *C. armeniaca*. We have therefore the synonymy *C. armeniaca* B. & C. (1857) = *C. Ditmari* Quélet (1877) = *C. Langloisii* E. & E. (1892).

C. Odyneri Quélet, on the larva of *Odynerus*, judging from the description and figure, is quite distinct from *Cordyceps sphecocephala* and *C. armeniaca*.

63. *Cordyceps Wittii* P. Henn.

Hennings described this species, which occurred on a large *Mygale*, as having semi-immersed, hemispherical, granuliform perithecia, with cylindrico-oblong asci, 50 × 14 μ, and linear ascospores, 40–45 × 1 μ, which were not septate and did not divide into part-spores.

In the type in Herb. Berlin, the long linear clavae appear pale red in the younger parts, but when magnified are reddish ochraceous, densely covered with minute red-brown ostiola. The older parts are now red-brown, horny, subtranslucent, cinnabar at the bases of the clavae, and here and there elsewhere. The perithecia are crowded in a peripheral layer, immersed, with slightly projecting ostiola, small, narrow ovoid, 0·2 mm. high, 0·06–0·08 mm. diameter, apex obtuse. The asci are cylindric, 4 μ diameter and over 80 μ long, and the ascospores are in two overlapping bundles. The ascospores are linear, slightly curved, attenuated slightly to each end, ends obtuse, 40–45 × 1·5 μ, multiseptate, not dividing into part-spores. This species is an *Ophiocordyceps*.

The type specimen was from Ecuador. There is another specimen in Herb. Berlin from Rio de Janeiro (Ule 632), also on *Mygale*, in which the insect is partly covered with bright cinnabar red mycelium.

Comparison of the type specimens shows that *Cordyceps Wittii* is the same as *C. caloceroides* B. & C. The latter, from Cuba, was collected "on the ground," but Cooke noted that it had the appearance of an entomogenous species. No doubt, the host insect had fallen to the

ground and disintegrated. The species will now stand as *Ophiocordyceps caloceroides* (B. & C.).

Montagne described a fungus on *Mygale* from Cuba as *Isaria gigantea*. The mycelium covering the insect was said to be yellowish white, and the clavae fuscous, 6–8 cm. long, 0·5–1 mm. thick. Except in the size of the clavae, the description does not suggest any relationship to *Ophiocordyceps caloceroides*. In *Fungi Cubenses*, Berkeley changed Montagne's name to *Cordyceps Montagnei*, but he did not have a specimen and the alteration was quite unjustifiable.

64. *Gordyceps sobolifera* (Hill) Sacc.

The large-spored *Isaria*, *I. Sinclairii*, is generally accepted as the conidial stage of *Cordyceps sobolifera*, though no evidence of that relationship has been adduced, except that both grow on *Cicada* nymphs. The Tulasnes recorded a conidial stage from Mexico, with conidia, $6{\cdot}5–10 \times 3{\cdot}5\mu$, which agrees with *Isaria Sinclairii*, and stated that the insect, when bearing the fungus, was called Chicharra by the Mexicans.

Support for that view is afforded by the processes, or "soboles," which sometimes occur on the stem of the *Cordyceps* clava. These processes are conidial, and their conidia are of the same order of dimensions as those of *Isaria Sinclairii*. Lloyd (*Mycol. Notes*, No. 42, June, 1916, p. 584), in recording a specimen of *Cordyceps sobolifera* from the Bahamas, stated that the soboles bore "only conidial spores, $4 \times 8\mu$." Again, Hennings, in describing as *C. Voeltzkowii* a specimen from Madagascar, which, from the specimen and figure, is undoubtedly *C. sobolifera*, stated that ovoid conidial stromata occurred about the middle of the stalk, with conidia, $6–7 \times 2–3\mu$.

In Herb. British Museum, there are specimens of *Isaria Sinclairii*, marked "*Cordyceps Sinclairii* (Berkeley), Tauranga, Poverty Bay, New Zealand, Walks of Archdeacon Williams' garden, Mantell Esq.," and others marked "*Sphaeria Sinclairii* Berkel., New Zealand, Dr Sinclair (1857)." These specimens have compact cylindric clavae, or clavae which terminate in a cluster of subglobose compact heads, in either case resembling *Cordyceps* clavae, but nevertheless only conidial. In Ceylon, the heads are sometimes lobed and loose, and evidently Isarioid, sometimes subglobose and compact. It is probable that the figures reproduced by Cooke from Fougeroux de Bondaroy represent conidial clavae, and the same would appear to be true of most of the forms discussed by Gray. There is, however, in Herb. British Museum, a specimen of the *Cordyceps*, marked "*Sphaeria sobolifera* (Hill) Gray's MS., West Indies."

Herb. British Museum also contains numerous specimens of *Isaria Sinclairii* from Mexico, with correspondence which states that the fungus is known in that country as "Chicharra" or "Animal Planta."

Some of these have been dried *ex* alcohol, and one of the latter is now a stag-horn clava, with a few stout branches, recalling Miquel's figure of *I. Cicadae*. In the light of these specimens it would appear advisable to adopt Miquel's name for the *Isaria*. Its synonymy will then be as follows:

Isaria Cicadae Miquel, in *Bull. Sci. Phys. et Natur. Néerlande*, I (1838), 85–86, Pl. I; *Sphaeria Basili* Taylor, in *New Zealand and its Inhabitants* (1844), p. 424 (*teste* G. H. Cunningham, *Trans. New Zealand Inst.* LIII (1921), 375); *Cordyceps Sinclairii* Berk., in *Fl. N. Zealand*, II (1855), 338; *Torrubia caespitosa* Tul., *Sel. Fung. Carp.* III (1865), 11; *T. Miquelii* Tul., *loc. cit.*; *Cordyceps Miquelii* (Tul.) Sacc. in *Michelia*, I (1878), 320; *C. caespitosa* (Tul.) Sacc. *loc. cit.*; *Isaria arbuscula* Hariot, in *Bull. Soc. Myc. France*, VIII (1892), 67; *I. amorpha* v. Höhnel, *Frag. z. Myk.* No. 276 (1909); *I. Harioti* Arnaud, in *Bull. Soc. Myc. France*, XXXI (1915), 20; *I. Cosmopsaltriae* Yasuda, in Lloyd, *Mycol. Notes*, No. 56, October, 1918, p. 806; *I. Mokanshawii* N. Gist Gee (cf. Lloyd, *Mycol. Notes*, No. 59, June, 1919, p. 854); *I. Sinclairii* (Berk.) Petch, in *Trans. Brit. Myc. Soc.* X (1924), 39.

In Herb. Berlin, there is a drawing of *Cordyceps sobolifera* from Japan, marked *C. Shiraiana* P. Henn. I have not been able to trace any description under the latter name.

65. *Cordyceps interrupta* v. Höhnel

Cordyceps interrupta was described by von Höhnel in *Fragmente zur Mykologie*, No. 207, from a specimen from Java. The clava divides into two or three thin branches, about 1 mm. diameter, each terminating in a discoid head, and it is peculiar in that similar heads occur, scattered along the branches, either lateral or partly encircling a branch. Von Höhnel was not able to determine the host, but suggested that the fungus was on the head of a beetle.

There is a specimen in Herb. Berlin, collected by Dr R. Schlechter in New Guinea, July, 1907, with the host, which is a Pentatomid.

Three species of *Cordyceps*, collected by Schlechter in New Guinea, are included in Herb. Berlin in a cover marked *C. Schlechteri* P. Henn., a name which apparently was not published. One of these is *C. interrupta*, another is *C. dipterigena* B. & Br. on a fly, and the third is *C. gentilis* (Ces.) Sacc. on a Hymenopteron.

66. *Cordyceps surinamensis* P. Henn.

The type of this species, described by Hennings in *Hedwigia*, XLI (1902), 169, is on a long-bodied fly, not on an ichneumon, and it is typical *Cordyceps dipterigena* B. & Br. This adds another to the list of synonyms given in *Trans. Brit. Mycol. Soc.* XVI (1931), 212.

67. *Cordyceps subunilateralis* P. Henn.

The type specimen of this species was described as having a subglobose or ovoid head, "longitudinaliter sulcata." It is an example of *Cordyceps unilateralis* which has two perithecial plates, one on each side of the thread-like stem, exactly opposite one another. It appears, therefore, to have a subglobose head with a meridional groove. The apex of the clava has been broken off, and the stump can be seen between the two plates. *C. subunilateralis* is a synonym of *C. unilateralis*.

68. *Cordyceps proliferans* P. Henn.

In *Trans. Brit. Mycol. Soc.* xvi (1931), 210, I suggested that *Cordyceps proliferans* P. Henn. (1904) and *C. Huberiana* P. Henn. (1908) were *C. bicephala* Berk.

I have since seen the type of *C. Huberiana*, which differs from *C. bicephala* in its stouter stalk, and in the shape of the head, which is cylindric, obtuse above, 9 mm. long, 1 mm. diameter. The type of *C. proliferans* was represented only by the insect in the specimens submitted to me, but from the figure and description it is the same as *C. Huberiana*, differing only in having a branched stem, each branch bearing a cylindric head.

These two specimens appear to be on the large ant, *Diponera grandis*. The cylindric head, however, is not universal in examples of *Cordyceps* on that insect, as another collection on the same host, in Herb. Berlin, Ule 2836, Jurua Miry, July, 1901, named *C. myrmecophila* Ces., is *C. bicephala* with the usual ovoid head.

Some *Cordyceps* which normally have ovoid heads, *e.g. C. nutans*, are known to vary and produce cylindric heads. It would seem preferable to regard *C. proliferans* as merely a variety of *C. bicephala*.

This cylindric form of *C. bicephala* resembles *C. rhizomorpha* Möller, which has a cylindric head, 10 mm. long, 2 mm. diameter. The type of the latter grew on the body of an insect which Möller could not determine, and it is now preserved as an exhibition specimen, and inaccessible. It does not, however, appear to be on the body of an ant, but probably a Hemipteron, and it differs from *C. bicephala* in the orientation of its perithecia.

Isaria myrmicidae Lloyd (*Mycol. Notes*, No. 62, February, 1920, p. 915, Fig. 1636) appears, from the figure and description, to be *Hymenostilbe melanopoda* (Speg.), the conidial stage of *Cordyceps bicephala*.

69. *Stilbum formicarum* Cooke & Massee

This species was described in *Grevillea*, xviii (1889), 8, from a specimen from Victoria, Australia, where it was found in a pitcher of a *Nepenthes*. The specimen, now in the Kew Herbarium, bears several linear clavae, arising from the body and legs of the insect. These

clavae are up to 8 mm. long, 0·25 mm. diameter, black, becoming white at the apex, flexuose, terete or irregularly flattened and twisted, slightly strigose at the base. According to Cooke, the apex was originally rose-coloured. The apex of the clava is acute or obtuse, or slightly inflated into a head, 0·4 mm. diameter and 0·5 mm. high. The outer layer, in the clava examined, was somewhat disorganised, and appeared to have been eaten off by some insect, but when perfect it was evidently a palisade layer of cylindric or clavate basidia, 15–18 × 3 μ. The conidia are apical, broadly clavate or obovate, one end truncate or both ends rounded, 6–9 × 2·5–4 μ.

This species is a *Hymenostilbe*, and it is the same as *H. melanopoda* (Speg.), described by Spegazzini, as *Isaria*, in *Fungi Puiggariani*, no. 468. *Hymenostilbe melanopoda*, like its perithecial stage, *Cordyceps bicephala*, has a stalk which is black below, but red at the apex when fresh, the red colour fading to white when the specimen is dried.

Spegazzini's species was also published in 1889. But the combination, *Hymenostilbe formicarum*, has already been employed for the conidial stage of *Cordyceps Lloydii* (*Trans. Brit. Mycol. Soc.* XVI (1931), 218), and consequently Cooke and Massee's specific name cannot be used, even if it should prove to be the earlier.

70. *Isaria dubia* Delacr.

Two specimens of *Cordyceps gracilis* Mont. & Dur. were collected at Ludlow on the Spring Foray of the British Mycological Society, May 28th–30th, 1932, one of which gave a good spore print. The part-spores were cylindric, ends truncate, 5–9 × 1·5–2 μ. A culture on quaker-oat agar, instituted from part-spores on June 3rd, developed an *Isaria* which agrees with *I. dubia* Delacr. Thus *Isaria dubia* is the conidial stage of *Cordyceps gracilis*.

Delacroix described the conidia of *Isaria dubia* as cylindric-fusiform, 5–6 × 1–1·5 μ, and in a specimen on the larva of a *Hepialus* from Staffordshire, April, 1931, they are narrow-fusoid, 4–6 × 1 μ, but in culture they were 5–9 × 1–1·5 μ.

The growth in culture consists of numerous (over fifty) suberect, slender white strands, radiating from the point of inoculation. These strands, or clavae, are about 5 mm. high, 0·1 mm. diameter, sparsely covered with divergent conidiophores.

71. *Isaria leprosa* Fries

Isaria leprosa was described by Fries in *Systema Mycologicum*, III, 272, from specimens collected in Germany, where it occurred on chrysalides in the same situations as *I. farinosa*. It was said to be fasciculate, flesh-coloured, with the thickened clavae and adjacent part of the stalk everywhere floccoso-pulverulent; short, a few lines high, but the clavae, if well developed, thickened and obtuse; the conidia very

abundant, very loose, globose, adhering to somewhat loose flocci, mixed with globules, whence to the naked eye the appearance was notably "floccoso-leprosa." A variety, *I. corallina*, was said to be very much branched and paler in colour.

Schroeter (*Krypt.-Fl. v. Schlesien*, III, Pt. 2, 276) recorded this species, citing specimens found by F. Cohn on pupae of *Orthosia incerta*, but though he described it as flesh-coloured he stated that the conidia were white.

Lindau (*Rabenh. Krypt.-Fl.* IX, 323) described the synnemata as red and the conidia as globose. In addition to the original record by Fries, he cited an occurrence at Leipzig. Lindau also enumerated *Isaria corallina* as a distinct species, citing the original record by Fries and an occurrence on lepidopterous larvae at Treviso in Italy. The latter record is from Saccardo (*Mycologia Venetae Specimen*, p. 187), who stated that it was distinguished from *I. farinosa* by the vinous colour of the whole fungus, its more slender stalk, and its rosy conidia which were elliptico-subrotund (not elongated).

Preuss (*Linnaea*, XXVI, 725) described another red *Isaria* as *I. cinnabarina*. It occurred on a pupa of *Sphinx ligustri* which had been reared in captivity. It was said to be everywhere flesh-coloured, with red conidia, and the description does not show any differences from *Isaria leprosa* and its variety, except that the conidia were given as oval.

In a specimen collected at Mulgrave Woods, Yorkshire, September 16th, 1930, on a pupa among dead leaves, the clavae occur chiefly in a dense cluster, about 5 mm. high, the whole of the exposed part of the fungus being deep pink and covered with conidia. One outlying clava, however, uncovered by removal of the leaves, has a thin white stalk. The heads are clavate or lobed, rather loose, with short thin flocci evident after the fall of the spores. The surface of the head appears granular, owing to the presence of small balls of conidia, resembling the surface of a *Beauveria*, but these are merely aggregations of spores. On the slightest touch these spore balls fall off, probably the reason why Fries described the conidia as "laxissima."

The conidiophore is spicarioid, with a main stalk, 3–4μ diameter, and prophialides and phialides in moderately distant, dense whorls. The prophialides are ovoid, attenuated below, $4 \times 2\mu$, and the phialides ovoid, attenuated above, $4–6 \times 1{\cdot}5\mu$, or subglobose, 3μ diameter, with a short sterigma. The conidia are catenulate, oval or oblong-oval, $2{\cdot}5–4 \times 1{\cdot}5–2\mu$, both ends rounded, or one or both ends subacute, sometimes biguttulate, with a few globose, 2μ diameter, hyaline, pink in mass.

The foregoing specimen was assigned to *Isaria leprosa*. An examination of other specimens of *Isaria*, collected in the same locality on the same date, has, however, discredited the autonomy of *I. leprosa*.

In one specimen, the pupa bears four short, thick clavae of *I. farinosa*. Two of these have a pink velvety patch extending up one side almost to the apex, the tip and the other side being white and farinaceous. The pink patch consists of the conidiophores of a *Sporotrichum*, more or less perpendicular to the clava, the white conidial masses of the *Isaria* persisting beneath it. This pink-spored *Sporotrichum*, which is parasitic on *Isaria farinosa*, has been described as *Sporotrichum Isariae* in *The Naturalist*, April, 1931, p. 102.

Another specimen has three groups of small stout clavae of *Isaria farinosa*. Two of them are normal, but in the third group the pink *Sporotrichum* involves the bases of the clavae, four in number, and ascends nearly to the tip of one of them.

On a third specimen, which bears seven clavae of *Isaria farinosa*, there is a brownish pink tuft of mycelium developing on the cocoon between the clavae; and a fourth specimen is similar.

A fifth specimen, bearing a single clava of *Isaria farinosa*, has patches of pinkish brown mycelium on the cocoon, and a dense covering of the *Sporotrichum* ascending the clava to half its height.

The mycelium of the *Sporotrichum* is brown to pinkish brown in the older parts, but pinkish or hyaline in the younger. The conidiophores are hyaline at first, but become pinkish brown below when old. The fungus had been collected previously, at Black Hills near North Wootton in March, 1930, on a pupa which was attacked by *Isaria farinosa* but had not developed a clava.

On re-examining the specimen assigned to *I. leprosa*, it was found that brown or purple-red hyphae, 4μ diameter, together with irregular purple-red masses up to 15μ across, were embedded in the hyaline tissue of the stem and branches. These hyphae appear to be the hyphae of *Sporotrichum Isariae*. Branched *Sporotrichum* conidiophores were not found among the spicarioid conidiophores of the *Isaria*. There were, however, single hyphae, 3μ diameter, and fascicles of cohering hyphae, 8μ diameter, bearing conidia terminally and laterally, which appear to belong to the *Sporotrichum*. It is almost impossible to distinguish between the spores of *Isaria farinosa* and those of *Sporotrichum Isariae*, as both appear hyaline individually, but the latter are, in general, the more oblong, with uniformly rounded ends.

Thus it would appear that *Isaria leprosa* is *I. farinosa* parasitised by a *Sporotrichum*. The evidence would be more definite if the typical *Sporotrichum* conidiophore could be found in the *Isaria*. In the other specimens reported, the *Sporotrichum* is evidently for the greater part external to the *Isaria* clava, but in the specimen assigned to *I. leprosa* it is internal.

It would seem probable that the names *Isaria leprosa* Fr., *I. corallina* Fr., and *I. cinnabarina* Preuss all refer to the same condition. *I. leprosa* was said to have globose spores, as in *I. farinosa*, but in all the speci-

mens of the latter which I have examined, the majority of the conidia are oval, though, as is usual in entomogenous species of *Spicaria*, a few may be globose.

72. *Isaria Orthopterorum* Petch, n.sp.

This species has been found on several occasions in Ceylon, and I have examined a specimen collected on Doi Sutape, Chengmai, North Siam, July, 1929. A photograph of two Ceylon specimens was published in *Trans. Brit. Mycol. Soc.* x (1924), 41. It occurs on Orthoptera.

The insect is covered by a thin, even, compact, white or cream-coloured layer of mycelium. From this arise numerous clavae, up to 6 mm. high. In general, the clavae have a stalk, up to 0·5 mm. diameter, terete or laterally compressed, terminated by a subglobose or lobed, tomentose head, up to 1 mm. diameter. Sometimes the stalk is branched, the branches terminating in separate heads, and in some specimens the clavae have no distinct heads, but are irregular with short lateral branches or tubercles, terete or flattened, sometimes slightly expanded at the apex. The clavae are at first white or pale ochraceous, and tomentose; when old they become glabrous, red-brown, and horny. The hyphae of the head branch and form a confused mass, and along them are produced clusters of globose phialides, 3μ diameter, each with a short sterigma which bears a chain of conidia. The conidia are hyaline, oval or subcymbiform, straight or curved, ends rounded, 4–5 × 2–2·5μ.

This species does not appear to have been described previously, though it is apparently not uncommon. I have had a specimen with larger clavae than those described above, but unfortunately it has been lost.

Isaria Orthopterorum Petch, n.sp.—Mycelio insectum membrana tenui alba vel pallide flava obducente; clavis albis vel pallide ochraceis, tomentosis, stilbiformibus, usque 6 mm. altis, stipite usque 0·5 mm. diam., tereti vel compresso, simplici vel ramoso, capite subgloboso vel lobato, usque 1 mm. diam.; conidiophoris vage ramosis, phialides globosos, 3μ diam., apiculatos, congregatos ferentibus; conidiis catenulatis, hyalinis, ovalibus vel subcymbiformibus, rectis vel curvis, obtusis, 4–5 × 2–2·5μ. On Orthoptera, Ceylon and Siam.

73. *Isaria floccosa* Fr., *I. strigosa* Fr., and *I. exoleta* Fr.

The above species of *Isaria* were described by Fries in *Systema Mycologicum*, III, 274–5. *Isaria floccosa* had almost the appearance of a *Hydnum*, and occurred on the larvae and pupae of *Bombyx jacobea*, *i.e.* the Cinnabar moth. *Isaria strigosa* was subulate, caespitose, arising from a more or less determinate patch of mycelium, and occurred on the pupa of *Noctua Ypsilon*. *Isaria exoleta* was elongated, caespitose,

fragile, filiform, pale fuscous, gregarious on a fibrillose mycelium, and occurred on the larva of *Noctua exoleta*.

In response to my query, Dr J. A. Nannfeldt has kindly informed me that there are no types of these three species in Fries's herbarium. He points out that Fries cites Siemers as the collector, and suggests that Fries saw the fungi in Siemers's collection in Germany. The present whereabouts of that collection does not appear to be known.

Isaria floccosa was recorded by Berkeley and Broome in *Notices of British Fungi*, No. 1906, on a caterpillar from Milton, Northants., but that specimen, now in Herb. Kew., is a *Hirsutella*, which has been described as *H. subulata* Petch. Berkeley also recorded it from Teneriffe, among the fungi collected on the *Challenger* Expedition, but the latter specimen is *Gibellula aranearum* (Schw.) Syd. It was also recorded as having been collected in Yorkshire, on a dead grub inside an empty hazel nut, but the specimen is not available and the record is extremely doubtful. I have not been able to trace any other records.

Isaria strigosa is recorded by Lindau in Rabenhorst, *Krypt.-Flora*, as having been found in Germany by Siemers (Fries's record), at Sachsenwald near Hamburg on a moth by Jaap, and on the pupa of *Halophila prasinana* in Holland by Oudemans. Lindau states that the conidia are oval, $4 \times 2\mu$, borne on simple conidiophores, 4μ diameter. As Oudemans merely said that the conidia were globose and very minute, Lindau's measurement was probably based on Jaap's specimen. But the latter, now in Herb. Berlin, is *Akanthomyces aculeata* Lebert.

In Herb. Berlin, there are specimens from Brefeld (Münster), labelled *Isaria strigosa*. These are on pupae. The pupa is covered by a continuous felted coat of mycelium, and from this arise fasciculate clavae, 1 cm. or more high, 0·5 mm. diameter, simple, or branched above, irregular, brown and fibrillose below, white and pulverulent or floccose above. The conidiophores are irregularly intertwined in an external conidiiferous layer, the hyphae being 5μ diameter, with conico-flask-shaped or broadly flask-shaped phialides, $6–9 \times 1·5–3\mu$, in clusters at a node, or on a short lateral branch. The conidia are oval, oblong oval, or ovate, $4–7 \times 2–3\mu$, in chains. These appear to be *Isaria ochracea* Boud.; hence, if they are correctly named, the latter name is a synonym of *I. strigosa* Fr.

I. exoleta Fr. does not appear to have been recorded again. But Cesati described a similar fungus, found on the pupa of *Bombyx* (*Orgyia*) *antiqua* in Italy, as *Cordyceps fuliginosa*. Cesati's fungus was an "*Isaria*," not a *Cordyceps*, but the details of both species are insufficient for comparison.

It will be evident that there can be no certainty about these three species, unless Siemers's collections are still in existence.

74. *Isaria Abutii* Lloyd

This name was published by Lloyd in *Mycol. Notes*, No. 68, January, 1923, p. 1180, Fig. 2378, for a specimen from the Gold Coast. Lloyd wrote: "The photograph is the best description. It grows on an insect which attaches itself to a sheath of grass. The filiform clubs are pure white, densely covering the host. Microscopic features I cannot make out, except of some mucor that has infected it."

The photograph suggests *Gibellula aranearum*, and Lloyd's observation that some mould had infected it supports that view, but it needs confirmation by examination of the type specimen.

75. *Akanthomyces aculeata* Lebert

In *Zeitschr. f. wiss. Zool.* IX (1858), 447, Lebert described *Akanthomyces aculeata*, gen. et sp.nov., a fungus on the moth, *Cerastis vaccinii*. The insect bore small, yellow-brown thorn-like processes along the edges of the wings, along the larger veins, and on the upper surface of the head, thorax, and abdomen, but they were more numerous and best developed on the under-surface of the body. The smallest were only 0·5–1 mm. high, while the longest scarcely exceeded 2–3 mm. The smaller were obtuse at the apex, but the longer were more thorn-like, with a fine, slightly curved tip. Their bases were united, especially on the under-side of the insect, by a uniform yellow covering of mycelium. So far, the description would apply to a specimen of *Isaria Sphingum*, growing on a moth which had fallen on its back when dead, so that the development of the processes was greatest on the under surface of the insect. Lebert, however, stated that the insect was captured alive in the condition described!

From Lebert's description and figures, it appears that the processes were solid, tough, composed of parallel hyphae united together, the outer hyphae giving off branches which curved outwards at an angle of from 60 to 90° and terminated as simple conidiophores, 20–25 μ long, 2·5 μ diameter, sometimes broader in the middle or at the tip, with an acute apex, closely packed together over the surface of the processes. Some of the branches were longer and sterile, thus forming paraphyses. The conidia were apical, oval or pyriform, often somewhat acute at one end, 3·3–5 × 2·2–3·3 μ.

Lebert's generic description is: Akanthomyces Lebert novum genus. Mycelium pallidum, flavum v. flavofuscum, spinis aculeatis unum ad tres mlm. longis superatum; fila in uno solum latere ramusculos in apice sporas ferentes exhibentia. The genus was not included by Saccardo in the *Sylloge Fungorum*.

In Herb. Kew., in the cover of *I. floccosa*, there is a specimen, "White Hill, Auchter House, Dundee, Nov. subfin. 1847. G. Lawson," which agrees with Lebert's figures and description. The moth bears numerous

processes, united at the base by pale yellow mycelium, along the back, and a few from the under side. The processes are terete, stout, equal, obtuse, or attenuated above, up to 2 mm. high, 0·5 mm. diameter, white or cream-coloured, tomentose. The processes are composed of parallel hyphae and are very tough. The outer layer is irregular, and consists of conidiophores curved upwards side by side, with numerous hyphae projecting 20μ beyond the layer of conidiophores. These barren hyphae are 1·5μ diameter, regular, or inflated to 2μ diameter at the tip. The conidiophores (phialides) are about 18μ high, 2μ diameter, cylindric, or slightly attenuated above, slightly curved, and arise singly on one side of a main hypha of the process, as figured by Lebert, or on clustered branches at the apex of a hypha which bends outwards. The barren hyphae and the conidiophores are not perpendicular to the axis of the process, but curve upwards; together they form a compact palisade layer. The conidia are hyaline, terminal, sessile, globose, 2–3μ diameter, or oval, 3–3·5 × 2–2·5μ.

In Herb. British Museum, there are several British specimens of *Akanthomyces aculeata* on moths. In one, from W. Carruthers, Moffat, Dumfries, August, 1861, the clavae appear to arise chiefly from the under-side of the insect, but the specimen has been compressed. The clavae are stout, cylindric or clavate, clustered, or divided above, pale yellow, pruinose, obtuse, up to 3·5 mm. high, 1 mm. diameter, covered by a dense layer, up to 100μ thick, composed of chains of conidia, but sometimes naked at the apex. The conidiophores (phialides) form an exterior palisade layer, and are clavate or cylindric, 18μ long, up to 4μ diameter, narrowed at the apex, apex truncate. The conidia are sessile, in very persistent chains, oval or pyriform, 4–5 × 3μ. Barren hyphae were not observed among the conidiophores.

In another British Museum specimen from St Mary's Isle, Kirkcudbright, the clavae are stout, cylindric, expanding at the apex, sometimes flattened and divided above, moderately tough. The phialides are 15–18 × 2–4μ, cylindric or clavate, slightly curved, with a short stout sterigma, 2–3μ long, and are accompanied by a few paraphyses. The conidia are abundant, ovate or oval, ends obtuse, 4–5 × 2–3μ, in chains.

Specimens in Herb. British Museum from F. Bond, one from the New Forest and the other without locality, have scattered clavae, short, stout, sometimes divided and lobed above, sometimes with a globose head. The phialides are not curved, and no paraphyses were observed. The conidia are abundant, ovate, oval, or clavate, 4–7 × 2·5–3μ, in chains, sessile or with the apex of the phialide attenuated into a short sterigma.

Other specimens in Herb. British Museum are one from Dartford Heath (Mr Lynch), apparently weathered, no conidia found; one from Devon (Miss Stawel), with few clavae, some short, stout, conical,

with a curved apex, others slender and acute, apparently all immature; one from the New Forest (Rev. G. Crawshay); three from the Isle of Purbeck, March 3rd, 1886, July 22nd, 1887, and October 21st, 1889 (E. R. Bankes); and two from Wareham, December 16th, 1880 (O. C. Farrer) and December 23rd, 1903 (E. R. Bankes). The last five specimens are on *Hepialus humuli* on gorse.

In Herb. Berlin, there are two weathered specimens, on moths on heather, Province Brandenburg, November 6th, 1927, Herb. E. Ulbrich, No. 7605; and a specimen from Sachsenwald near Hamburg, October, 1907, collected by O. Jaap, the latter specimen being in the cover of *Isaria strigosa.*

As already stated, *Akanthomyces aculeata*, at first sight, would be taken for a small specimen of *Isaria Sphingum.* Thaxter (*Mon. Laboulb.* I, 359), when substituting *Rhachomyces* for *Acanthomyces* Thaxter, because of the prior use of *Akanthomyces* by Lebert, stated that Lebert's fungus was "probably identical with *Isaria Sphingum.*" But, on the specimens available, it is easy to distinguish *Akanthomyces aculeata* from *Isaria Sphingum* by its short stout clavae, usually thickened upwards, and often divided or lobed at the apex. On microscopic characters, the differences are not so distinct, and some of the characters enumerated by Lebert are not constant. Thus, the phialides are not always curved, and paraphyses may be lacking. The degree of toughness of the clava varies, but the clava in the available specimens is never loosely built, as in West Indian conidial examples of *Isaria Sphingum.* All the available European specimens are *Akanthomyces aculeata.*

In American specimens of *Isaria Sphingum*, the conidia occur on minute clavae, conical at the base, with a shortly-stalked globose head (*I. pistillariaeformis* Pat.), or with a short, slender apical appendage, as described by Vincens. The long, whip-like clavae are sterile, or bear perithecia, and apparently they are not at first conidial. The conidia are cylindric, or narrow-oval, or, according to Vincens, globose, and the phialides are clavate or flask-shaped.

In specimens from the East Indies, conidia have been found on the long clavae, and on minute clavae suddenly attenuated into a slender apical appendage, but the *I. pistillariaeformis* form has not been found in that region. The conidia are cylindric, clavate, oval, or globose, and, in some examples, have a mucous coat. The phialides are cylindric or clavate.

It is possible that the European fungus is merely a geographical form of *I. Sphingum*, but the perithecial stage is required before the question can be decided.

Lebert described a perithecial form, which appears to be *Cordyceps Sphingum*, as *Akrophyton tuberculatum*, and Maire published the combination, *Cordyceps tuberculatum* (Lebert) Maire, to replace *C. Sphingum* (Tul.) B. & C. But there now arises the doubt whether Lebert's

specimen was of European or American origin. He found it in the Museum at Geneva, but did not record where it had been collected. The host was said to be *Sphinx pinastri*, but the specific determination of moths attacked by such fungi is usually doubtful. The specimens of *Cordyceps Sphingum* which the Tulasnes described were in the Paris Museum and were of American origin, and it is probable that the same is true of Lebert's. But if his specimen were of European origin, the substitution of his specific name for the Tulasnes' is open to question in the present state of our knowledge.

Cooke (*Vegetable Wasps*, etc., p. 128) wrote that *C. Sphingum* had been found in Switzerland, his statement being no doubt based on Lebert's record.

For the present I would prefer to retain Lebert's name for the European species which has been assigned to *Isaria Sphingum*. It appears doubtful whether it will be possible to maintain *Hymenostilbe* Petch distinct from *Akanthomyces* Lebert.

HELOTIUM CILIATOSPORUM BOUDIER

By B. BARNES

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(With 5 Text-figures)

Helotium ciliatosporum(1) was first recorded in this country by Wakefield(9), from material found on the vascular skeleton of a herbaceous stem, in October, 1918, at Weybridge; it does not seem to have been recorded since.

In October, 1930, I found numerous apothecia of a species of *Helotium* on the stumps of old stems of Michaelmas Daisy in my garden in South-east London. Apothecia continued to form until about the middle of November, 1930, when the fungus disappeared. During that autumn, the garden was searched several times in order to determine what substrata were inhabited by the *Helotium*. It was always more abundant in the place where it was first seen. There, the Michaelmas Daisy had formed a particularly dense clump, one side touching a wall, the rest shielded at the base by thick plants of *Antirrhinum*. Other clumps of Michaelmas Daisy, less dense and less sheltered, harboured smaller crops of apothecia. A few apothecia were found on stumps from 1929, of double-flowered *Achillea Ptarmica*, and of *Solidago serotina*; none was found on stumps of the same age of *Delphinium elatum*, *Paeonia officinalis*, *Alyssum argenteum*, *Astrantia major*, *Erigeron multiradiatus*, *Doronicum plantagineum*, *Chrysanthemum indicum*, *Coreopsis grandiflora*, *Centaurea macrocephala*, *C. dealbata*, *Phlox paniculata*, *Veronica amethystina*, *Mentha* sp., *Melissa officinalis*, *Monarda didyma*, *Lavandula officinalis* and *Asparagus officinalis*. *Helotium scutula* was present on *Mentha*, *Melissa*, and, very densely, in one clump of Michaelmas Daisy from which *Helotium ciliatosporum* appeared to be absent.

Helotium ciliatosporum was not found between November, 1930, and September, 1931, though it was looked for from time to time. In August, 1931, a large plant of Michaelmas Daisy was cut down before it had flowered, and at the same time a plant of *Melissa officinalis* was similarly treated; at this time, apothecia of *Helotium* could not be found in the garden. Apothecia became abundant in mid-September, after wet weather, appearing first in the place where they were first noted in 1930, and later in other masses of Michaelmas Daisy. None developed on the stems cut down in 1931, even in late October, when the upper parts of these stumps were dead, and kept moist by fallen leaves.

By mid-October, the plant of *Melissa* cut down in August had sent up a rich crop of new leafy shoots, hiding the stumps of 1930 and 1931. Although the weather was rather dry and warm in October, heavy dews kept these stumps wet; the dead stumps of 1930 bore plenty of apothecia of *Helotium ciliatosporum*, but the moribund stumps of 1931 bore none.

During the autumn of 1931, a few small apothecia of *Helotium ciliatosporum* were found on stumps of *Centaurea macrocephala* dating from 1930. The substratum was sheltered by old hanging leaves, and by a growth of new shoots from the base of the plant. The stem of *Centaurea macrocephala* is woody at the base, with a fairly large pith cavity; the proportional development of wood and pith is about the same as that found in the rapidly growing branches on a recently pollarded poplar. Twigs of poplar of this kind, cut in 1930, had been thrust in the ground in April, 1931, in the neighbourhood of places where *Helotium ciliatosporum* had occurred during the previous autumn; apothecia never developed on these twigs.

Material collected in 1931 was submitted to Miss E. M. Wakefield and to Mr W. D. Buckley. They very kindly looked over the specimens, and both agreed that the fungus was *Helotium ciliatosporum*. Specimens were supplied to the Herbarium, British Museum (Natural History) and to the Herbarium, Kew.

As in 1930, so in 1931, *Helotium ciliatosporum* disappeared about the middle of November.

In the spring of 1932, most of the plants of Michaelmas Daisy in the garden were lifted, divided and replanted; in consequence, dead stumps were mostly lost. The clump which first provided the fungus, as well as two others, both close to walls, was purposely left undisturbed. Watch was kept for apothecia throughout the year, but none was seen until September 24th, after wet weather. On that day, a few crowded groups of apothecia were found in the original locality, on the ends of stumps just projecting above the soil. They could not be found anywhere else in the garden, not even in dense clumps of *Melissa*, where dead stems abounded, well sheltered by leafy shoots. On September 30th, a few young apothecia were noted on *Melissa*, and there was a fair crop on all the undisturbed plants of Michaelmas Daisy. On this day, pieces of dead stem dating from 1931 were taken from *Mentha*, *Buddleia variabilis*, *Veronica amethystina* and *Lychnis coronaria* and thrust into the ground among the richest groups of young apothecia. Wet weather came on in early October. By the 9th, *Helotium ciliatosporum* was abundant on stumps of *Melissa* and Michaelmas Daisy, and nowhere else. Periodic inspection during the wet weather showed that other species were not being invaded, and that the fungus was not spreading to the pieces of stem placed in its way. The weather became drier in late October and November, and

Helotium ciliatosporum decreased in vigour and disappeared as in previous years.

Once only during the three autumns covered by these observations have *Helotium ciliatosporum* and *H. scutula* been found together: the former occupied the lower and wetter positions, the latter the higher and drier ones on a stump of Michaelmas Daisy.

Helotium ciliatosporum has been found in the garden on dead stems of a few composites and of one labiate, but not on all the composites and labiates grown there. It is not a parasite, for it has been found only on dead material either on erect stumps of the previous year, or on fallen material of uncertain age. Apothecia have been seen only in the autumn, and nothing has been seen of the fungus at other times of the year. Sclerotia do not seem to be formed, and ascospores have not been found on or in the soil, or in scrapings from old stems. The manner of survival remains to be determined. It is possible that the mycelium perennates in the substratum.

The distribution of *Helotium ciliatosporum* in the garden seems to be conditioned largely by humidity. It develops most freely close to the soil, on dead stems surrounded by objects which check movement of the air and so favour quiet, moist conditions. Mere wetness of the substratum does not seem to be sufficient, for apothecia have been found on partly detached pieces of bark, but not on dead leaves of about the same consistency and equally wet. The results of a few experiments (p. 80) indicate that excessive humidity is unfavourable, for although growth is not prevented, orderly development and spore formation are hindered or stopped.

Apothecia are most easily seen on stumps, still erect and attached to the underground parts of the plant, but they also occur on pieces of stem lying loose on the soil. They develop on dead bark and on bare wood; apothecia on bark come away cleanly with it, indicating that they have not grown out from the underlying wood and pushed through the bark. Particularly large specimens are often found attached to the surface of the cavity left by the shrinkage and breakdown of the pith. This cavity is often full of water in wet weather, a circumstance which probably favours development of the fungus. When the stump is erect and unsplit, apothecia occur only on the outer surface and on the surface of the pith cavity just below the open end; splinters from split stumps may bear apothecia anywhere. Apothecia seldom arise from erect stumps at a height exceeding 5 cm. above ground-level, and, in general, those formed close to the soil have longer stalks than those formed higher up (Fig. 1). The length of the uppermost ones is usually less than the diameter of the cup. On a prostrate piece of stem, the apothecia attached to the under surface have longer stalks than those arising from the sides, and apothecia emerging from the top surface may be nearly sessile.

Observations on undisturbed material, and the results of experiments (p. 82) indicate that although the orientation of the fruit body is in relation to the incident light, yet the orientation is not very exact. As the spores are ejected by puffing, accurate placing of the apothecium is of secondary importance.

Freshly opened apothecia look very much like small agarics. They have a convex shining hymenium of a bright ochraceous yellow, with faint indications of an inrolled margin. The glossiness does not seem to be due to moisture, but apparently to the smooth hymenium formed by the crowded tips of asci and paraphyses. Once puffing has occurred, the rolled margin becomes more obvious, and the apothecium does not regain its glossy surface, even if placed in water or kept in a moist atmosphere. Two hundred and seven apothecia, taken from samples gathered from time to time while the species has been under observation, have been measured in an absolutely fresh state. The diameters ranged from 0·5 to 4·0 mm., the heights from 0·5 to 5·5 mm.; the average diameter was 1·8 mm., the average height 1·9 mm. Apothecia shrink very rapidly when taken into a moderately dry atmosphere. Young and turgid specimens were brought in quickly from the garden, mounted under the camera lucida and their outlines at once traced. Further tracings were made at regular intervals. The drawings reproduced in Fig. 2 show that the shrinkage is speedy and pronounced.

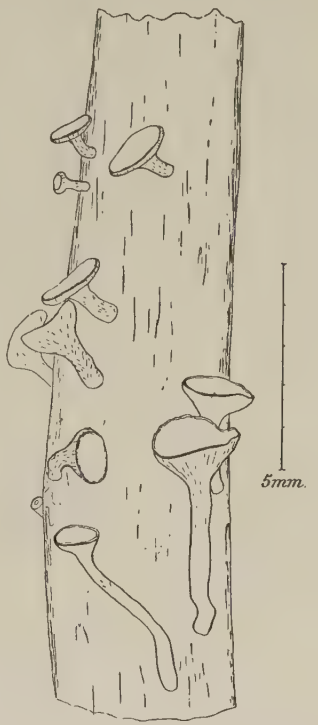

Fig. 1. *Helotium ciliatosporum* Boud. Group of apothecia on old stem of Michaelmas Daisy. × 5·5.

During October and November, 1931, several pieces of stem bearing a few apothecia were suspended vertically in stoppered jars in such a way that the lower end of the stem just dipped into water. Other pieces taken from places where the fungus was common, but not bearing apothecia, were similarly treated. The jars were placed on a shelf about 6 ft. from a window, and left undisturbed for some weeks. Rudiments of apothecia soon developed on all in large numbers. They formed most freely from parts of the stem not already bearing apothecia, though some arose from among the fruit bodies already present. One piece of stem, 8 cm. long, produced more than one

hundred rudiments, a crop greatly exceeding in density anything seen in the garden.

The rudiments grown in the closed jars were long and tapering, some attaining a length of more than 3 cm. In the saturated atmosphere there were no indications that the distance of the rudiment from the water had any influence upon the length reached. In the earliest stages of development, the rudiments grew straight out from the substratum, showing no reaction to light, but when they were about 5 mm. long, their tips began to curve towards the light. At this stage, reached in four to five days, the young fructifications were just like those figured by Grove(5) for *Helotium scutula*. Irregular curvatures began to appear when growth had been in progress for about a fort-

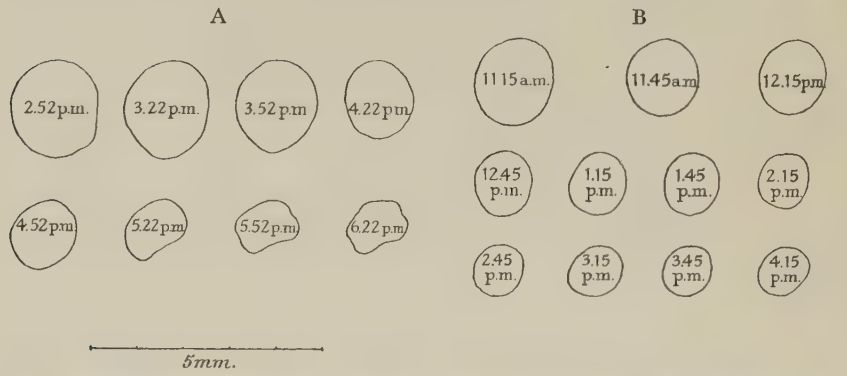

Fig. 2. *Helotium ciliatosporum* Boud. Outlines of apothecia allowed to dry in the air, and drawn under the *camera lucida* at intervals of half an hour. A, from an apothecium which had puffed. B, from a freshly opened apothecium.

night, and, as the cultures aged, the orientation of the tips lost all reference to the direction of incident light, so that, finally, a disorderly appearance was presented.

Although elongated rudiments developed freely in these cultures, very few mature apothecia were obtained. Rudiments about a fortnight old often bore a small, yellowish terminal swelling. Twenty of these were examined, and none was found to contain asci. Of the few apothecia which matured, most were somewhat abnormal. Generally, the deformation was slight, being a slight asymmetry of the cup. Five developed a hymenium on the surface of a spoon-shaped extension of the stalk (Fig. 3*a*), and two had a branched stalk, one branch ending in a fairly regular cup, the other in a sterile, yellowish pad (Fig. 3*b*, *c*). Some of the elongated rudiments formed in the last week of October, 1931, remained light coloured and apparently healthy until early in January, 1932. They then turned brown, collapsed and decayed, leaving the substratum bare.

The production of these curious bodies seems to be a reaction to

a saturated atmosphere. They are giant versions of normal rudiments, and they have never been seen on stumps in the garden, nor have they formed on pieces of stem placed in open vessels or in Petri dishes, and kept slightly moist; under such conditions, crops have been obtained agreeing in number and character with the normal growths formed out of doors. When, however, material in Petri dishes was kept very

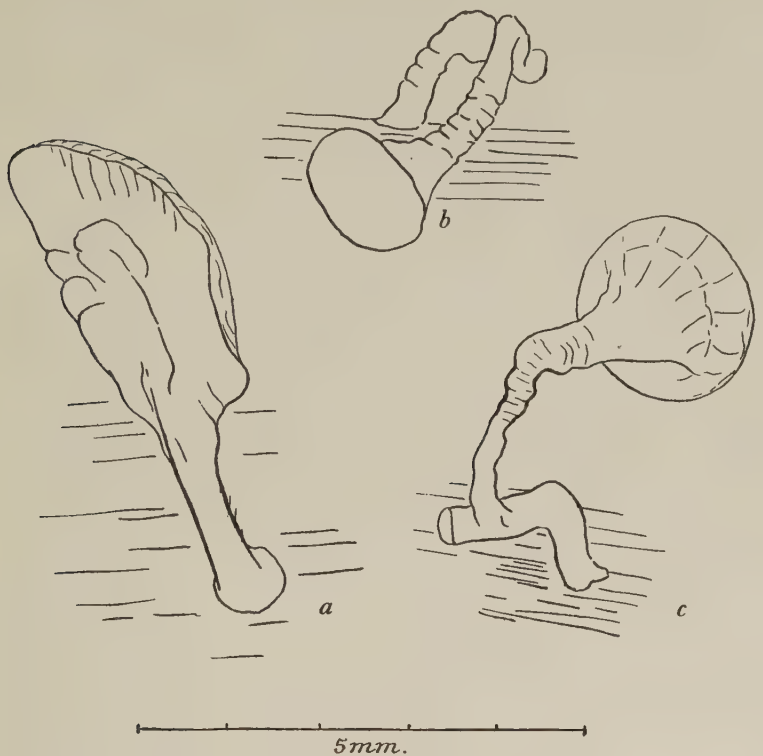

Fig. 3. *Helotium ciliatosporum* Boud. Abnormal forms of apothecia obtained from material kept in a saturated atmosphere.

wet, by maintaining a layer of water on the bottom of the dish, limited crops of elongated rudiments developed.

Attempts were made to induce mature apothecia to revert to a vegetative condition by placing them in contact with moist surfaces in a saturated atmosphere, but nothing happened, except that the apothecia finally rotted. Freeman(3) obtained vegetative growth from fruit bodies of *Xylaria Hypoxylon* treated in this way. It may be conjectured that the non-fertile hyphae of the apothecia of *Helotium* are more definitely inclined, physiologically, towards the reproductive

side of the balance than are the non-fertile hyphae of the stromata of *Xylaria*, and therefore less well able to resume vegetative growth.

In one of the jars described above, a piece of stem, on which many rudiments had developed during the autumn of 1931, was left undisturbed during 1932. The well-fitting stopper prevented evaporation, so that everything remained saturated with water. After the rudiments decayed in January, 1932, nothing happened until early November. On November 3rd, 1932, a few elongated rudiments had begun to form, and, by the middle of the month, a fair crop was present. The rudiments remained fresh until the first week in December, when they began to shrivel and turn brown; none developed an apothecium.

This matter is of some interest. The resumption of activity by the fungus coincided roughly in time with the autumnal activity in the garden. Humidity alone could not be responsible, for the material had been saturated for months. The onset of relatively low temperatures is not a sufficient explanation, for, if it were, fruit bodies should have developed at similar temperatures in early spring. The position appears to be complicated; it is possible that a piece of stem supporting an active mycelium becomes temporarily staled, and that a period of inactivity on the part of the fungus is necessary to allow the staling products to disappear before growth can begin again. I do not know of any detailed work on the staling of woody substrata by fungi. Some observations on *Xylaria Hypoxylon* indicate that this species does not stale its substratum sufficiently to prevent renewed growth each year, for it has fruited in my garden every autumn since 1924 on a partially buried piece of elm, about 1 in. in diameter and 6 in. long. So small a piece of wood is probably easily staled by an active mycelium, but the persistent fruiting of the *Xylaria* on the wood indicates that the staling is not permanent.

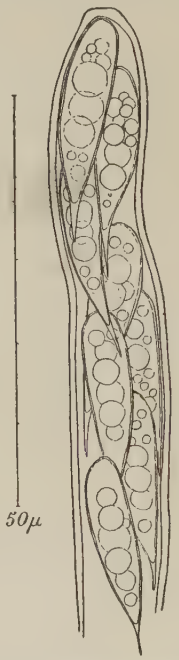

Fig. 4. *Helotium ciliatosporum* Boud. Ascospores in upper part of ascus.

The renewed growth of *Helotium ciliatosporum* on a piece of stem which had previously borne abortive rudiments only, suggests that the mycelium may perennate in the substratum.

Special attention has been paid to the ascospores of *Helotium ciliatosporum*, for not only are these spores a peculiar feature of the species, but they are of interest in estimating its systematic position.

The ascospores are vaguely biseriate, and, as they lie in the ascus, the lower end of the spore is always attenuate and prolonged into a short pointed appendage, 4–5μ long (Fig. 4). The upper end of the spore also usually bears a pointed appendage, but as this is often inserted obliquely it cannot always be seen on spores still in the ascus. When loose spores are examined in water (Fig. 5), two appendages

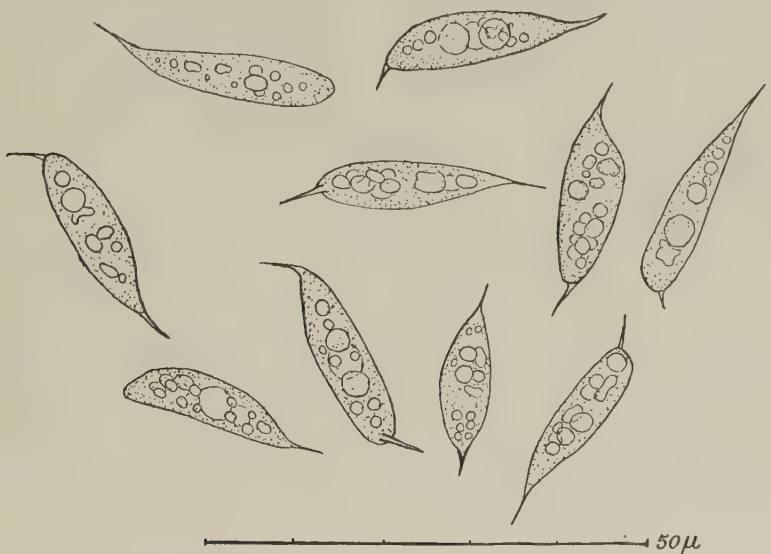

Fig. 5. *Helotium ciliatosporum* Boud. Ascospores, from a field selected at random.

can generally be demonstrated on every one of them by pressing the cover-slip and so causing the spores to roll about. Occasionally a spore is found which is slightly bent and which bears a very short appendage on the curved upper end of the spore, and rarely spores with the basal appendage only are seen.

Several samples of spores taken from various apothecia have been measured; the results appear in Table I.

Table I. *Measurements of ascospores of* Helotium ciliatosporum (*dimensions in* μ)

	Length																
Breadth	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
3	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—
4	2	—	2	2	3	2	1	1	—	—	—	1	—	—	—	—	—
5	2	1	6	10	13	18	23	19	20	8	1	4	2	—	—	—	—
6	—	—	6	1	17	19	23	38	39	25	16	7	5	1	1	—	—
7	—	—	—	—	1	3	9	20	22	25	18	21	7	3	3	1	1
8	—	—	—	—	—	—	1	2	3	3	5	8	3	1	1	—	1
9	—	—	—	—	—	—	—	—	1	1	—	1	—	—	—	—	—
Totals...	4	1	14	13	34	42	57	81	85	62	40	42	17	5	5	1	2

The spores thus fall within the range $15–31 \times 3–9\mu$, with an average of $22{\cdot}5 \times 6\mu$. Most of the spores fall within the range $19–26 \times 5–7\mu$, with a similar average.

These measurements may be compared with those given by various authors for the ascospores of *Helotium ciliatosporum*, and of species which appear to be related to, if not identical with it; details appear in Table II.

Table II. *Dimensions of* Helotium-*like fungi with appendaged spores*

Species	Author	Ascospores
Ciboria ciliatospora	Fuckel	$24 \times 6\mu$
Ciboria ciliatospora	Saccardo & Berlese	$22–24 \times 5–6\mu$
Ciboria ciliatospora var. minor	Saccardo & Berlese	$20–24 \times 6–7\mu$
Phialea appendiculata	Oudemans	$20–26 \times 4–5\mu$
Belonioscypha ciliatospora	Rehm	$20–26 \times 4–6\mu$
Helotium Verbenae	Cavara	$20–22 \times 4–5\mu$
Helotium ciliatosporum	Wakefield	$20–27 \times 4–5\mu$

These spores fall within the range $20–27 \times 4–7\mu$, and give an average of $22{\cdot}8 \times 5{\cdot}2\mu$. The spores of *Helotium ciliatosporum* which have been measured show a range which more than covers that of all the species noted in Table II, and consequently measurements of the ascospores do not provide any useful criterion of identification.

A careful comparison of fresh material with the descriptions given by Rehm(7) of *Belonioscypha ciliatospora*, and by Wakefield(9) of *Helotium ciliatosporum*, leaves no doubt that the fungus discussed here is identical with that described by these authors.

Rehm(7) placed the fungus in his genus *Belonioscypha* on an assumption that the ascospores ultimately become septate. His figures ((7), p. 706) are slightly modified copies of some of the figures of *Ciboria ciliatospora* given by Saccardo and Berlese(8). Septate spores are not figured, and though septate paraphyses are mentioned in the description of both genus and species, the paraphyses are not septate in the figures. In my material, one or two septa are present in most paraphyses, but they are not strongly developed, and often require searching for. Later, Rehm ((7), p. 1267) states, on the authority of Bresadola, that *Belonioscypha ciliatospora* is merely a young form of *Helotium scutula*, that the appendages of the ascospores soon disappear, and that the ascospores become septate. As *Helotium scutula* had been found, although sparingly, in association with a fungus agreeing in its characters with *Belonioscypha ciliatospora*, and as the two seemed quite distinct in their characters and mode of occurrence, it was clearly necessary to investigate the ascospores further.

Accordingly, ascospores were examined as they lay in mature asci. Others were taken from the surface of fresh apothecia, and still others from puff deposits obtained by drying apothecia in watch glasses or

in tubes. Further samples were examined from apothecia kept moist for two or three weeks, and therefore of some age, from material similarly treated and then dried off for some weeks, and from apothecia dried off as soon as collected and kept for some months. The results of some of these examinations follow.

On October 23rd, 1931, apothecia were collected, and five hundred spores were immediately examined. All showed one appendage, and about 80 per cent. bore two; septa were not observed. On the same day five hundred spores, from a puff deposit some days old, failed to show a single convincing septum. In these spores, vacuoles were less abundant than in freshly ejected spores, and the granular cytoplasmic contents, greenish when mounted in water, were abundant and obvious. In some of the spores, the contents were divided into two parts, separated by a narrow clear space, which, under low powers, looked much like a septum. The use of a good $\frac{1}{12}$ in. objective failed to confirm this however, and staining with cotton blue did not reveal the presence of any septa. The clear space was apparently filled by a hyaline liquid without granules.

A number of spores were mounted in an aqueous solution of potassium nitrate, saturated at 12° C. There was a slight general contraction of the contents, but no evidence of shrinkage away from a central septum.

On February 8th, 1932, ascospores were taken from three apothecia, collected on September 22nd, 1931, kept moist for a fortnight, and then dried off; all the spores had been ejected from the asci. The results appear in Table III.

Table III. *Examination of old ascospores of* Helotium ciliatosporum

Class of spore	Number of spores from apothecium			
	No. 1	No. 2	No. 3	Totals
Contents undivided	382	583	634	1599
Contents divided, septa not present:				
Contents divided into two	20	35	15	70
„ „ „ three	5	9	8	22
„ „ „ four	4	11	8	23
„ „ „ five	1	4	1	6
„ „ „ six	2	—	—	2
„ „ „ seven	1	1	—	2
False appearance of septation, contents divided into two	15	9	13	37
	430	652	679	1761

In all the samples of ascospores examined, appendages were equally abundant.

Results such as these do not support the assertion that the ascospores ultimately become septate and lose their appendages, and they

afford no evidence that *Helotium ciliatosporum* is a young stage of *H. scutula*. I have not seen germinating spores of *H. ciliatosporum*, but as Rehm figures ungerminated spores of *H. scutula* ((7), p. 771) without appendages, and with definite septa, it would appear that he was comparing ungerminated spores of *Belonioscypha ciliatospora* with these.

Although detailed information was not preserved, the examination of some ascospores of a pallid form of *Helotium scutula* found in the garden indicated that these spores never bore appendages, and that they were slightly smaller than those of *H. ciliatosporum*.

It seems hardly worth while to embark upon an attempt to examine the status of the several species set out in Table II, as the evidence is insufficient. If *Helotium*-like fungi with appendaged spores can be found on *Mentha* and *Verbena*, it may then be possible to decide if the species described by Oudemans(6) and by Cavara(2) are the same as *Helotium ciliatosporum* Boudier, to which they appear to be closely related. *Ciboria ciliatospora* Fuckel(4) is too large, and, if his figure of a curved ascospore represents a fair sample, as it presumably does, there is here another point of difference. The descriptions and figures given by Saccardo and Berlese(8) do not agree, for the description runs, "Ascomata cum stipite 1 cent. alta, 2–3 mill. lata," while the habit drawing shows long-stalked apothecia with cups nearly as wide as the total height of the fructification. Rehm adopts these figures as his illustrations of *Belonioscypha ciliatospora*, but, until living material of *Ciboria* can be compared with good material of *Helotium ciliatosporum*, the synonymy given by Rehm will hardly be accepted.

Summary

1. *Helotium ciliatosporum* Boudier has developed freely in autumn on dead stems of herbaceous perennials in a garden in South-east London.

2. Cool humid conditions appear to favour the growth of the fungus.

3. A saturated atmosphere checks normal development, the apothecia being mostly replaced by elongated, sterile rudiments.

4. The mycelium probably perennates in the substratum, and the periodicity may be due to the interruption of growth by a transitory accumulation of staling products in the dead stems.

5. *Helotium ciliatosporum* Boudier seems to be identical with *Belonioscypha ciliatospora* Rehm, but it is not a young stage of *Helotium scutula* Karst.

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SOME NEW SPECIES OF *PENICILLIUM*

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(With Plates IV and V)

Of the four species of *Penicillium* here described, and believed to be new to science, three were isolated during an investigation of the fungal infections of manufactured cotton goods, carried out in the laboratories of Messrs Boardman and Baron, Ltd., of Great Harwood, during the years 1927–9. *P. pallidum* (No. 76) and *P. varians* (No. 91) were obtained as single colonies on plates from samples of yarn showing no sign of mildew, and may be regarded as part of the latent infection carried by almost all samples of cotton. *P. Raistrickii* (No. 100) was isolated from a sample of mouldy cotton yarn and was responsible, at any rate in part, for the damage.

The remaining species, *P. Charlesii* (No. 127), was obtained in 1931 by the late Mr J. H. V. Charles, working at the London School of Hygiene and Tropical Medicine, from a sample of mouldy Italian maize which was under examination for the purpose of obtaining cultures of the "green-spot" organism, *P. brevi-compactum* Dierckx (syn. *P. stoloniferum* Thom). The new species first attracted attention on account of its unique biochemical reactions, an account of which will appear elsewhere in due course.

Cultural characteristics are recorded mainly from colonies on Czapek's solution agar in Petri dishes. All measurements, except those made from living cultures, are from specimens taken from cultures on Czapek agar and mounted in lacto-phenol. Measurements were made with a 2 mm. objective and a 15× micrometer ocular, arranged so that the value of one micrometer division was exactly 1 μ.

P. pallidum n.sp. (Catalogue No. 76.) Pl. IV, figs. 1 and 2

Coloniis albis, lente cremicoloribus, velutinis aut funicularibus; reverso incolorato, deinde ochraceo, paulo zonato; hyphis fructiferis repentibus aut fasciculatis; conidiophoris ex pedicellis, 70–120 × 2·3–3 μ, spinulosis; penicillis plerumque asymmetricis, sed aliis biverticillatis, 35–55 μ longis, in toto spinulosis; metulis 11–14 × 2–2·5 μ; basidiis 11–12 × 2 μ; conidiis glabris, 3·2–4 × 1·5–2·2 μ; coloniis gelatinam lente liquefacientibus.

Colonies growing well on all common media at temperatures up to 37° C., white, becoming cream-coloured in age, velvety to the naked eye but more or less definitely funiculose under low powers of

the microscope; reverse at first colourless, becoming faintly zoned with pale buff; gelatine liquefied completely in 3–4 weeks; conidiophores arising from creeping hyphae or from definite ropes of hyphae, many originating from clearly differentiated foot-cells as found in *Aspergillus*, others terminal on long trailing hyphae which gradually enlarge to the diameter of the conidiophores, 70–120μ in length by 2·3–3μ in diameter, tapering slightly towards the penicillus, definitely roughened; penicilli mostly asymmetric but frequently biverticillate, 35–55μ in total length; metulae rough, 11–14μ by 2–2·5μ in diameter; sterigmata finely spinulose, bluntly pointed, 11–12μ by 2μ; conidia smooth, elongate 3·2–4μ by 1·5–2·2μ; conidial chains at first roughly parallel, becoming tangled in age, adhering fairly persistently in fluid mounts.

The author is indebted to Dr Charles Thom (private communication) for pointing out the existence of foot-cells of the type regarded by Thom and Church (1) as a primary generic character of *Aspergillus*. Dr Thom has suggested that, on account of this peculiarity, the species does not fall into any of the great divisions of *Penicillium* hitherto described, and that it should be made the type of a new section, presumably "The Pedicillata." The case of *P. varians*, however (see below), suggests that the presence of foot-cells is not of primary diagnostic importance, and that other more prominent characters should determine the placing. Colony characteristics, the basis of Thom's grouping (2), place *P. pallidum* amongst the "Asymmetrica-Funiculosa," close to *P. Putterillii* Thom.

P. varians n.sp. (Catalogue No. 91.) Pl. IV, fig. 3

Coloniis glaucis dein griseis, paulo floccosis aut funicularibus; reverso incolorato aut aurantio-brunneo; conidiophoris plerumque ex hyphis fasciculatis, 40–50 × 2–2·8μ, asperulis, brunneolis; penicillis biverticillatis, metulis 10–14 × 2–2·5μ; basidiis densis, acuminatis, 10–15 × 2μ; conidiis pyriformibus aut ellipticis, glabris, 3–4 × 1·5–2μ; coloniis gelatinam non liquefacientibus.

Colonies growing moderately well on all usual media at temperatures up to 37° C.; on wort agar slightly floccose, bluish green rapidly becoming greyish green then grey, in age covered with sterile mycelium, dirty white, often with patches of pink or yellow; on Czapek agar slightly floccose or funiculose with irregular production of conidial areas bluish green, turning grey, sometimes with basal felt of gelatinous masses of hyphae, pale brown to orange-brown; reverse variously colourless, spotted with faint purple or, in cultures exposed to light, definitely coloured brownish orange; conidiophores arising as short branches from interlacing hyphae or definite ropes of hyphae, articulate, slightly roughened, definitely coloured pale yellowish brown but not dematiacious, 40–50μ by 2–2·8μ; penicilli symmetrically biverticillate; metulae 10–14μ, occasionally longer, by

2–2·5μ; sterigmata closely packed, acuminate, 10–15μ by 2μ; conidia ovate or pyriform, smooth, 3–4μ by 1·5–2μ.

On Raulin's solution conidial production is sparse, the growth consisting of layers of sticky, gelatinous mycelium, accumulating to a thickness of an inch or more.

Dr Thom has pointed out to the author that the conidiophores sometimes arise from more or less definite foot-cells (cf. *P. pallidum*). The latter structures are, however, both less frequent in occurrence and less definite than in *P. pallidum*, and *P. varians* is so definitely allied to the well-known species in Thom's group "The Biverticillata-Symmetrica(2)," in cultural characteristics, morphology and biochemical reactions, that there seems to be little ground for separating it on account of the presence of rudimentary foot-cells alone.

P. Raistrickii n.sp. (Catalogue No. 100.)
Pl. IV, fig. 4, Pl. V, figs. 5 and 6

Coloniis glaucis dein griseo-viridibus, demum brunneolis, velutinis; reverso incolorato; conidiophoris asperatis, usque 250μ longis, 3·5–4μ crassis; penicillis divaricatis; metulis clavatis, ternis quaternis quinisve, 10–13 × 4–4·8μ; basidiis 7·5–9 × 2·6–3μ; conidiis globosis, 2·2–2·7μ diametris, glabris, catenis conidiorum in densis columnis compaginatis; sclerotiis abundantibus, albis, ellipticis vel globosis, usque 180μ longis.

Colonies growing rapidly on most media at temperatures up to 30° C., rate of growth much less above 30° C. and nil at 37° C.; bluish green then greyish green and finally somewhat brown, velvety; reverse persistently uncoloured, showing masses of sclerotia; conidiophores arising from the substratum, up to 250μ long, 3·5–4μ in diameter, rough; penicilli typically divaricate, comprising 3–5 monoverticillate heads united into a fairly compact whole; metulae clavate, sometimes very slightly roughened, 10–13μ by 4–4·8μ; sterigmata closely packed on each individual metula, 7·5–9μ by 2·6–3μ; conidia globose or nearly so, smooth, 2·2–2·7μ in diameter, conidial chains packed into diverging solid columns; sclerotia produced abundantly, hard, feeling like grit under a cover-glass, consisting of masses of irregular-shaped thick-walled cells, white to dirty white, globose or ovoid, up to 180μ in long axis.

This species is noteworthy chiefly on account of its very free production of sclerotia. It belongs to the group, the "Asymmetrica-Divaricata," where such structures have not previously been observed.

P. Charlesii n.sp. (Catalogue No. 127.) Pl. V, figs. 7 and 8

Coloniis late crescentibus, atro-viridibus dein griseo-viridibus vel viridi-fuscis, velutinis; reverso incolorato in cultis juvenilibus, viridulo vel brunneolo in cultis senibus; conidiophoris ex hyphis repentibus,

Fig. 1

Fig. 2

Fig. 3

Fig. 4

aut simplicibus aut irregulariter ramosis, asperulis, 2–2·2μ crassis, apice 4–5μ incrassato; penicillis monoverticillatis; basidiis 7·5–9 × 2·2–2·5μ; conidiis ellipticis aut subglobosis, spinulosis, 3–3·2 × 2·2–2·8μ, catenis conidiorum in longis columnis compaginatis; coloniis in aqua Raulinii atro-viridibus; reverso roseo, aqua aureo-brunnea.

Colonies growing rapidly on all common media, rich dark green becoming greyer and finally brownish olive, strictly velvety becoming somewhat wrinkled in age; reverse on solid media uncoloured or faintly green or brown in old cultures, on fluid media (particularly on Raulin's solution) a beautiful rose-pink with solution at first pink then golden brown; conidiophores arising from creeping hyphae, simple or variously loosely branched, occasionally with a fairly compact group of metula-like branches, each branch bearing a monoverticillate penicillus (the species is typically in the group "Monoverticillata-Ramigena" Thom); conidiophores slightly roughened, 2–2·2μ in diameter, enlarged at the tip to a vesicle-like swelling, 4–5μ in diameter; sterigmata roughly parallel, closely packed, 7·5–9μ by 2·2–2·5μ; conidia subglobose to ovate, spinulose, 3–3·2μ by 2·2–2·8μ, packed in long, slender columns.

Grateful acknowledgment is made of the advice given by Dr Charles Thom, of the U.S. Department of Agriculture. Thanks are also due to Messrs Boardman and Baron, Ltd., of Great Harwood, for permission to use the photographs and for the gift of the culture collection made in their laboratories.

EXPLANATION OF PLATES IV AND V

All the photographs, except Fig. 6, are of specimens mounted in lacto-phenol.

Plate IV

Fig. 1. *P. pallidum*. Typical conidiophores. × 500.
Fig. 2. *P. pallidum*. Conidiophore with foot-cell attached. × 500. As frequently happens when making preparations of *Aspergilli*, the foot-cell has broken away from the adjacent mycelial cells. It is easy to find foot-cells with both ends still attached, but these are usually enveloped in masses of mycelium and are impossible to photograph.
Fig. 3. *P. varians*. Typical conidiophores arising from rope of hyphae. × 500.
Fig. 4. *P. Raistrickii*. Conidiophore with "divaricate" head of five verticils. × 500.

Plate V

Fig. 5. *P. Raistrickii*. Living culture in Petri dish, showing heads with several divergent columns of spore-chains. × 50.
Fig. 6. *P. Raistrickii*. Sclerotia. × 100.
Fig. 7. *P. Charlesii*. Branched conidiophore forming a fairly compact penicillus. × 500.
Fig. 8. *P. Charlesii*. Conidiophore with irregular branching, typical of the "Monoverticillata-Ramigena." × 500.

REFERENCES

(1) Thom, C. and Church, M. B. *The Aspergilli* (1926).
(2) Thom, C. *The Penicillia* (1930).

REVIEW

Dry Rot in Wood. 2nd Edition. Department of Scientific and Industrial Research. Bulletin No. 1. Forest Products Research Laboratory, Princes Risborough, Bucks. 1933. 34 pp. 7 Pl. 2 text-figs. Price 1*s*.

Probably most of those who are interested in mycology spend a considerable amount of time in answering questions about dry rot in timber. Judging from my own experience, dry rot is far more common in this country than is usually supposed and causes far more damage than is generally realised. Added to this, and probably accounting for it, is the amazing ignorance both about the biology of *Merulius lacrymans* and about the methods by which attack may be prevented or controlled. It is important, therefore, that there should be a pamphlet of up-to-date information to which the general public can be referred, and so attention is called to the second edition of the D.S.I.R.'s pamphlet *Dry Rot in Wood.*

The first edition was published in 1927. In the present edition "the opportunity has been taken to revise it thoroughly and to incorporate additional matter which has become available as the result of further experience and experiment." The pamphlet is in three sections: Part I (15 pp.), Fungi causing dry rot in wood, by K. St G. Cartwright and W. P. K. Findlay; Part II (8 pp.), The detection and practical treatment of dry rot, contributed by H.M. Office of Works; and Part III (10 pp.), Precautions to be taken in the use of timber in new buildings to prevent outbreaks of dry rot, contributed by the Building Research Station of the D.S.I.R.

In my opinion the first part is a great improvement on the previous edition; it is illustrated by seven excellent plates. It is always difficult to decide how best to present facts to the general public but in a limited space Messrs Cartwright and Findlay have managed to crowd in a good deal of information in a manner which will make it easy to find the required details. In addition to *Merulius lacrymans*, *Poria vaporaria* and *Coniophora cerebella*, mention is also made of *Paxillus panuoides*, *Fomes cryptarum*, *Lentinus lepideus* and *Stereum frustulosum* as timber destroyers. The note on *Fomes cryptarum* refers to it as attacking old oak and states that it "has been reported as the cause of serious damage in some old buildings, a notable instance being the Palace of Versailles." This, though a little ambiguous, is the first record of the occurrence of this fungus in this country. I received a specimen in 1924 and was enabled to identify it by seeing the Versailles material in Paris; since then two or three specimens have turned up. It would be interesting to have a full account of the structure and biology of this fungus.

The resistance of certain woods to dry rot is noted. Canadian Western red cedar (*Thuja plicata*) contains a natural preservative, and red-wood (*Sequoia sempervirens*), which is also mentioned, must be remarkably resistant to fungal attack, for logs will lie about in the forests apparently sound for centuries.

Among many useful features is a "Schedule of fungi causing dry rot," which contrasts the characters of mycelial cords, surface growths, fruit-bodies, with additional general remarks, in five wood-rotting species.

The remaining two parts of the pamphlet give much useful practical information. It would probably have been better to have had all the three parts co-ordinated, for the greatest need at present is to impress upon builders, architects and surveyors the reasons for and against certain practices; to give rules of general application is often a waste of time and often leads to useless expense. It is usually overlooked that a single fruit-body of *Merulius lacrymans* produces enough spores to infect every building in the country and that the fungus will not develop if there is proper ventilation. The pamphlet suitably ends with two full-page sketches, one showing "Precautions to ensure air stream through buildings below floors," and the other "Danger with normal types of construction."

J. R.